PUBLISHED EVERY SATURDAY BY
THE W. J. JOHNSTON COMPANY, Limited.
167-176 TIMES BUILDING, NEW YORK.
Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York.

New England Office, 28 Hathaway Building, Boston.
Western Office, 465 The Rookery, Chicago.
Philadelphia Office, 927 Chestnut Street.

SUBSCRIPTION IN ADVANCE, ONE YEAR $3.
(Including Postage in the U. S., Canada or Mexico.)

Address all communications to
THE W. J. JOHNSTON COMPANY, Ltd.,
Times Building, New York,
OR ANY OF THE BRANCH OFFICES.

VOL. XXI. NEW YORK, JAN. 28, 1893. NO. 4.

CONTENTS.

EDITORIAL: PAGE
Paragraphs ... 61
ILLUSTRATED ARTICLES:
Suggestions for Metering Devices, by S. D. Mott ... 63
Experiments in Electric and Magnetic Fields, Constant and Varying, by E. C. Rimington Wythe Smith ... 63
Experimental Researches on Alternate Current Transformers. —IV., by Dr. J. A. Fleming ... 65
Calculation of a Small Electric Motor of Ten Kilogrammetres. —I., by E. Meylan ... 70
The New Separable Lamp ... 71
The Stanley Transformer ... 72
Cutter's Mine Socket ... 72
MISCELLANEOUS:
Ether and Electricity, by A. Slotetow ... 62
Experiments with High Frequency Electrical Discharges, by A. A. Campbell Swinton ... 64
Electrical Recording Meters, by C. D. Haskins ... 64
A New Electrical Periodical ... 67
Moonlight Tables for February, 1893 ... 67
A Correction ... 67
Electricity at the World's Fair ... 68
World's Fair Notes ... 68
Some Mechanical and Electrical Analogies, by F. Bedell and A. C. Crehore ... 70
Important Meeting of the Advisory Council of the Chicago Electrical Congress ... 71
Meeting of the St. Louis Electric Club ... 71
The Pruyn Elevated Electric Railway ... 71
A Franchise Awarded ... 71
New Books ... 72
FINANCIAL INTELLIGENCE: The Electrical Stock Market, 73; New Incorporations, 73.
SPECIAL CORRESPONDENCE: New York Notes, 73; New England Notes, 74; Philadelphia Notes, 74; Washington Notes, 74; Western Notes, 74; English Notes, 75.
NEWS OF THE WEEK: The Electric Light, 75; The Electric Railway, 75; Personal, 75; Miscellaneous Notes, 75.
INDUSTRIAL AND TRADE NOTES ... 75
BUSINESS NOTICES ... 76
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS ... 76

Publications of the W. J. Johnston Co., Ltd.

THE ELECTRICAL WORLD. An Illustrated Weekly Review of Current Progress in Electricity and Its Practical Applications. Subscription, in advance, one year $3.00

JOHNSTON'S ELECTRICAL AND STREET RAILWAY DIRECTORY, Containing Lists of Central Electric Light Stations, Isolated Plants, Electric Mining Plants, Street Railway Companies—Electric, Horse and Cable—with detailed information regarding each; also Lists of Electrical and Street Railway Manufacturers and Supply Dealers, Electricians, etc. Published annually 5.00

THE TELEGRAPH IN AMERICA. By JAS. D. REID. 894 royal octavo pages, handsomely illustrated, Russia ... 7.00

DICTIONARY OF ELECTRICAL WORDS, TERMS AND PHRASES. By EDWIN J. HOUSTON, A. M. Second edition, entirely rewritten. 5,000 definitions, 562 double column octavo pages, 570 illustrations 5.00

THE ELECTRIC MOTOR AND ITS APPLICATIONS. By T. C. MARTIN and JOS. WETZLER. With an appendix on the Development of the Electric Motor since 1888. By Dr. LOUIS BELL. 315 pages, 353 illustrations. 3.00

THE ELECTRIC RAILWAY IN THEORY AND PRACTICE. The First Systematic Treatise on the Electric Railway. By O. T. CROSBY and Dr. LOUIS BELL. Octavo, 400 pages, 179 illustrations 2.50

ALTERNATING CURRENTS. Treated Analytically and also Treated Graphically. By FREDERICK BEDELL, Ph. D., and ALBERT C. CREHORE, Ph.D. Uniform in size and style with Crosby & Bell's "Electric Railway" 2.50

PRINCIPLES OF DYNAMO-ELECTRIC MACHINES and Practical Directions for Designing and Constructing Dynamos. By CARL HERING. Sixth thousand, 279 pages, 59 illustrations 2.50

ELECTRIC LIGHTING SPECIFICATIONS or the Use of Engineers and Architects. By E. A. MERRILL. 175 pp. 1.50

THE QUADRUPLEX. By WM. MAVER, JR., and MINOR M. DAVIS. With Chapters on Dynamo-Electric Machines in Relation to the Quadruplex, Telegraph Repeaters, the Wheatstone Automatic Telegraph, etc. 126 pp., 63 illustrations 1.50

THE ELEMENTS OF STATIC ELECTRICITY, with Full Description of the Holtz and Töpler Machines. By PHILIP ATKINSON, Ph.D. 228 pages, 64 illustrations 1.50

LIGHTNING FLASHES. A Volume of Short, Bright and Crisp Electrical Stories and Sketches. 160 pages, copiously illustrated 1.50

ELECTRICITY AND MAGNETISM. A Series of Advanced Primers. By EDWIN J. HOUSTON, A. M. 1.00

RECENT PROGRESS IN ELECTRIC RAILWAYS. Being a Summary of Current Advance in Electric Railway Construction, Operation, Systems, Machinery, Appliances, etc. Compiled by CARL HERING. 386 pages, 120 illus. 1.00

ORIGINAL PAPERS ON DYNAMO MACHINERY AND ALLIED SUBJECTS. Authorized American Edition. By JOHN HOPKINSON, F. R. S. 1.00

DAVIS' STANDARD TABLES FOR ELECTRIC WIREMEN. With Underwriters' Rules, Instructions for Wiremen and Linemen, Plates of Circuits and Useful Data. Third Edition. Revised by W. D. WEAVER 1.00

UNIVERSAL WIRING COMPUTER for Determining the Sizes of Wires for Incandescent Electric Lamp Leads and for Distribution in General Without Calculation, with Some Notes on Wiring and a Set of Auxiliary Tables. By CARL HERING. 44 pages 1.00

EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY. By NIKOLA TESLA. 146 pages, 30 illus. 1.00

LECTURES ON THE ELECTROMAGNET. Authorized American Edition. By Prof. SILVANUS P. THOMPSON. 287 pages, 75 illustrations 1.00

WHEELER'S CHART OF WIRE GAUGES 1.00

A Lecture by Nikola Tesla. IT has been rumored for some time that Mr. Nikola Tesla would deliver a lecture before the National Electric Light Association next month, and now it is definitely announced by President Ayer that such is the case. The lecture will be a public one, illustrated by numerous experiments, and will be looked forward to with great interest by all those who have followed the course of Mr. Tesla's work during the past few years. Few lectures have ever created such a widespread interest either here or abroad as those already given by Mr. Tesla, and it is safe to predict that the forthcoming one will prove no exception. It is to be regretted that other prominent electricians do not more often avail themselves of such opportunities of keeping the public in touch with their work.

The New Westinghouse Separable Lamp. THE secrecy which has been maintained in regard to the new incandescent lamp which has been so long promised by the Westinghouse Electric and Manufacturing Company has at last been broken. Unusual interest has been aroused in this new product on account of the peculiar situation in which the lamp industry has been placed by the numerous recent decisions in favor of the General Electric Company. Elsewhere we give a cut of one of the forms of the new lamp and a description of its salient features, which will be read with interest by all connected with the electrical industry. Whether or not it evades the Edison patent must of course be decided by the courts. The General Electric Company claims that it does not, the Westinghouse Company that it does. Whether all the claims that are made for it will be substantiated, time alone can determine. One step in advance, however, has evidently been made, and that is a cheapening in the cost of manufacture. This is certainly an important step, and, if it has been gained without sacrificing other important requirements, is in itself equivalent to a gain in efficiency and life.

Mechanical and Electrical Analogies. IT has not infrequently been remarked with what facility the mechanical engineer adapted himself to that allied profession, electrical engineering, and one need not go far for the reason. In both mechanical and electrical engineering we have to do with transmissions and utilizations of forces, which being interconvertible must of necessity follow more or less closely the same laws. In fact, both of these professions are but branches of that more comprehensive one included under the generic term engineering, and as our knowledge broadens, so do these branches converge to the parent stem. It was not long after the invention of the dynamo that the various types differing materially in outward appearances from each other were recognized as but variations from a single type and dependent upon principles common to all. A recognition, therefore, of common relations between different branches of a given profession, and between the various professions or sciences themselves, is one that grows with our knowledge, and is itself an index of our knowledge. The recognized analogies between mechanical and electrical laws have been many, and new ones are constantly being discovered. Some of the latest of these have been formulated by Dr. F. Bedell and Dr. A. C. Crehore, and are presented in tabular form in another column.

Herz, Whipple, et al. THE soil from which the electrical industry has sprung has been one of phenomenal fecundity. From a single seed cast by the wayside, as it were, has grown a harvest unparalleled in the history of the world. What wonder is it then that a few weeds should have grown up and in their rankness have sapped the vitality of the more desirable crop. Surely such a soil might be expected to be productive of phenomenal growths of the one as of the other. But as a matter of fact it has been peculiarly free from the undesirable products which in other directions have obtruded themselves so plenteously. To be sure there have been charlatans and parasites without number, but they have so usually betrayed themselves by their bray as to have discredited the cause but little. But in striking contrast to these stand out the careers of Herz and Whipple. The one in France, the other in the United States, both pursued somewhat similar plans to gain prominence. Each hid his dishonesty behind a faultless exterior—each gained his end through an attractive presence. The one followed journalism to gain a standing in the electrical world, the other gained a standing by means of journalism. The operations of Herz have set two continents by the ears, those of Whipple have been confined to a much smaller radius. One instinctively admires the ability which carries on operations of great magnitude, while he despises that which is content with smaller pickings. While Herz is accused of the unlawful appropriation of millions, Whipple has in like manner been convicted of obtaining hundreds. For several years it has been known that Frederic H. Whipple, well, and for a time honorably known to the electrical community through his publications, "Whipple's Reports," and "Whipple's Electrical and Street Railway Directory," was crooked. His crime was the fraudulent issue of drafts. The following dispatch from Pittsfield, Mass., where he was tried on one of these charges, tells the rest: "The jury in the case of Frederic H. Whipple, for obtaining money under false pretences, were charged by the judge and retired at 3:38 this (Friday) afternoon. They returned in just four minutes with a verdict of guilty on the first count."

A New Department in The Electrical World. IT may not be generally known that there are published every month in the English, French and German languages over 150 issues of periodicals devoted exclusively to electrical subjects, besides which there are probably twice as many more journals devoted to other branches of science and engineering which sometimes have articles on electrical subjects. Although matter is sometimes duplicated in different journals, while some is in the nature of news items, or is merely of local interest, there is, nevertheless, so much that is of general interest and permanent value that the electrical engineer who is anxious to keep abreast of the times finds it impossible to look over it all unless he is a man of leisure. Even if he had the time he would in most cases find it expensive to subscribe to all the more important of these journals. There are also many technical and commercial men who are interested in one or two special branches, but have to look over all the journals in order to pick out the articles which interest them particularly. We believe, therefore, that we are expressing the opinion of most of our readers in saying that there has arisen a growing need for a classified summary or digest of all the current electrical literature on electrical subjects, and it is to meet this need that THE ELECTRICAL WORLD will in its next issue start a new department in which it will endeavor to give its readers the benefit of a library of journals by publishing each week a more or less brief summary of the most important matter that has been published during the preceding week. Its aim will not be to give a mere index of titles and authors, nor to merely publish sections of the articles, but it will endeavor to give, as far as possible, the essence of the most important matter, classified under separate headings, together with a reference to where the original may be found, and in some cases, perhaps, accompanying it with editorial comments and back references to other allied articles. Whenever the article is of such a nature that it cannot very well be summarized, our brief will at least show the reader the nature of the article, whether theoretical, practical or commercial, and will state where the original may be found. Busy men will therefore be enabled to keep posted on all the published periodical literature of the day through the medium of this weekly summary. The department will be conducted by Mr. Carl Hering.

Rapid Transit in New York. WITH the failure of the Rapid Transit Commissioners to find a satisfactory bidder for the underground project for New York the hope of immediate application of electricity on a general scale has largely subsided, and the electrical fraternity have lost the interest they once manifested. It is not a feeling of despair that pervades the community, but rather one of resignation to the perversity of existing conditions. The old saw that "All things good come to him who waits" is one the truth of which the electrician must learn to realize. The logic of the times points clearly to the inevitable ultimate triumph of electricity over other motive powers, not because of its greater cheapness, but because of its greater adaptability, its greater cleanliness, and its greater appropriateness. The world will not stand still because a few who are not posted proclaim that it does not move, nor will the mandate of the king cause the tide to cease to flow. Obstructions in its path but increase the pressure which ultimately is sure to triumph and sweep everything before it. Immediate relief to the congested thoroughfares of our great metropolis is to be sought in an extension of our present elevated system, and the past week has developed several plans for appropriating new streets to this end. What it all will amount to remains to be seen, but the general feeling seems to be that the present company, the Manhattan, will be the fortunate recipient of the new and valuable franchises. The elevated structures are indeed unsightly and the noise and the droppings a nuisance, but they might be made less so, and the popular uproar against the prostitution of additional streets which greets the announcement that they are to be taken might have been much less earnest, had the existing companies been in the past more considerate of their patrons than they are usually credited with having been. They have in fact created for themselves an opposition so strong as almost to be insurmountable, but we maintain that with improved management and with greater facilities this may in a measure be overcome. History shows no record of an agency so potent for good as electricity has proved itself in the last few years. In less than half a decade the street car horse and mule have been largely emancipated. The bobtail car and the filthy drygoods box on wheels have given place to those more in keeping with our modern civilization, and the improvement in management of street car lines has kept pace with the improvement in rolling stock. The elevated roads in their day were a great improvement, but they have not kept abreast of the times. We feel satisfied that if electricity were substituted for the present methods on the elevated roads, if the management would adopt a more liberal policy toward the traveling public, they would remove much of the hostility against which they now have to contend and would number friends where they now see none but enemies.

Ether and Electricity.—Part I.*

BY A. STOLETOW.

This subject occupies scientists of the present day to the highest degree. Before our eyes it becomes one of the grandest combinations of the epoch, and once more the question rises "What is electricity?" Throughout the nineteenth century this enigma has been the object of numerous researches. Electrical phenomena have been deeply studied; and this study has already become very fertile in practical results, permitting us to satisfy numberless needs, to realize the most fanciful projects, and yet the inner working of electrical phenomena remains still a deeper mystery. I will not say that, at the present moment this mystery is perfectly clear. Twenty-five years ago the first step in this direction was taken and the remarkable progress of these last two years has shown in a palpable manner that we are on the right track, that the foundations of the theory are well grounded. The initiative belongs to the genius of Clerk Maxwell, who has been dead about a dozen years. (Nov. 5, 1879). If Faraday, with his unequaled scent, had already discovered the right path, it was necessary to have a Maxwell to develop his thoughts and give to them a palpable form. In 1865 appeared a memoir by Maxwell, "La Theorie Dynamique du Champs Electromagnetique," and soon after he developed his ideas in his celebrated "Traite d'Electricite et de Magnetisme" (1873). Already at this time many facts corroborated Maxwell's theory, but recent researches are a positive triumph for it.

"It is impossible to study this remarkable theory," says Hertz, "without experiencing, from time to time, the feeling that mathematical formulas have, so to speak, an independent existence, a meaning of their own, that they are more intelligent than we are, more intelligent even than their authors, and that they give us back more than we have put into them."

Maxwell's ideas are founded upon ether, the same medium in which light and heat are propagated. It is then natural to expect that the new theory of electricity will be in contact with the old theory of light. But it is not a simple contact, it is an absorption of one theory by the other. The undulatory phenomenon called light becomes a particular case of the mechanical action of ether, which embraces a collection of phenomena bearing, at the present moment, the name of electromagnetism.

Physics treats of different forms of energy and their reciprocal relations. Ordinary matter is the molecular vehicle for the conveyance of kinetic and potential energy. The different forms of this energy and their transformations are made manifest to us in the phenomena of universal gravitation, in the actions of molecular forces (comprising the phenomena of acoustics) and also in the phenomena of heat, in so far as it concerns the heat of bodies, looked upon as the energy of vibratory movements of material molecules.

In the cases most accessible to study, we discover that energy is transmitted from one part of material substance to another gradually and successively; that is to say, that this transmission of energy is effected by means of an interposing medium, and requires a finite time.

But it happens that it is difficult to follow this transmission, either because it is impossible to grasp the length of time throughout which this transmission lasts, or because we do not see the substance or medium which serves as an intervening agent. We cannot deny a priori the possibility of a direct transmission of energy through space without the intervention of some medium; but we can affirm that if this direct action takes place it must be instantaneous, as, perhaps, universal gravitation.

But, if we admit that the transmission of energy requires a finite time, even very slight, we are obliged to conclude that it is effected with the intervention of a medium, and in the cases where direct observation does not reveal to us the presence of any ordinary matter we must admit some other—an imponderable matter.

For the first time we are compelled to recognize the existence of this particular matter, when we study the transmission of the light and heat of the sun and other heavenly bodies through space where there can exist no other matter (unless there are traces of very rarefied gases).

The great velocity of this transmission (300,000 kilometers per second) and the nature of this phenomenon do not admit of gases as this intermediary substance. Everything proves, in fact, that the action of the propagation of light is in a certain measure analogous to that of the propagation of sound. Now this has, in more or less dense air, a velocity of 300 metres a second, and no gas, no ordinary matter, could possibly impart a velocity a million times greater. The polarization of light waves bears an additional argument; it indicates that the vibrations which transmit light are transversal. Gases and liquids admit of longitudinal vibrations only. It is therefore necessary to admit that space is filled with a particular medium capable of taking up transversal vibrations. To this medium they have given the name "ether." In studying the nature of the waves which it propagates, we shall learn some of the properties of this medium.

The density of this medium, however small it may be, is still considerably greater than that of the gases that one might regard as the traces of very rarefied atmospheres of planets.

Ether seems to be from its vibrations not a liquid nor a gaseous fluid but rather an elastic and rigid body; indeed, it is only in rigid bodies that we find transversal vibrations.

The free movement of heavenly bodies is not at all in contradiction to this apparent rigidity of ether. Ether opens and closes, letting these bodies pass, as water permits a wire to pass through it. Ether can also be drawn along, to some extent, by these bodies, as water is by a sponge. Indeed, these movements are very slow compared with the vibrations of a light wave. It is also possible for the same substance to act like a solid as to rapid movements, and like a liquid as to relatively slow ones.

Tar, to take an example of a viscous body, can resound like steel, and yet, put a layer of it in a glass containing water and you will see that a cork placed at the bottom under the tar will slowly pass through it; likewise a leaden ball will pierce it rapidly, falling from the surface of the tar to the bottom of the glass.

Ether is the instrument of transmission of undulatory energy, now kinetic now potential, which energy we call light or heat. The word light is too narrow to designate this radiating energy, since all rays are not perceptible to the eye. It is no less inconvenient to give to it the name of radiant heat, as is often done, because one calls by the name, radiant heat, either that particular form of energy (purely kinetic) which has produced the ray, or that which appears when the ray is absorbed by some body whose temperature is raised.

The ray is a transitory form of energy; it may become energy again but it may also be transformed into mechanical (latent heat) or chemical work.

Formerly rays were divided into heat, light and chemical action rays. They now know that each ray can produce a heat and chemical effect. It is only the light action that remains the exclusive property of those waves occupying the middle part of the spectrum, those waves of from 400×10^{12} to 800×10^{12} vibrations per second. All the other waves can act on the retina only when they have first been transformed into rays of this particular type.

Light is only a small part of the waves that the sun sends us; to express it as in acoustics, it is approximately one of the six octavos of the solar spectrum.

In the obscure part of the infra-red spectrum, Mr. Langley has found stars and terrestrial bodies of relatively low notes, of 15×10^{12} vibrations per second and length of wave of 1-50 millimetre, while the ultra violet part of the solar spectrum contains waves of $1{,}000 \times 10^{12}$ vibrations per second with a length of wave of .000290 millimetre.

Our atmosphere does not let pass the "lowest" or the "highest" waves coming from the stars, but in the spectrum of the voltaic arc the superior limit is found still further back (the length of the wave is .000180 millimetre). The known limits will be extended without doubt when our means of observation shall be more perfect.

Ether fills all the pores of bodies—these intermolecular spaces always exist, however continuous the substance appears—and it is in a certain manner feebly bound to ponderable matter. In more or less transparent bodies, it still keeps its property of propagating certain waves, but having become more dense or less elastic, it transmits them with a less velocity, which also depends upon the length of the wave. The index of refraction is inversely proportional to the velocity of propagation.

In opaque bodies the energy of the rays is absorbed by their superficial layer (which is always more or less transparent). The waves meeting a certain obstacle to their propagation are extinguished there; the energy is transformed into heat (a new form of energy of ponderable matter), from ether.

The study of the energy of rays compels us to recognize the existence of ether; it demonstrates it and we shall see below new proofs of it.

There is an exaggerated scepticism which drives some, even to-day, to regard ether as something hypothetical. In the present condition of science, ether is not a hypothesis, but a reality as much as air and water.

According to Sir William Thomson, ether is the only substance the existence of which we are obliged to recognize. It is only the abuses which this word has occasioned that can explain this mistrust, this "fear of ether," which, like a hereditary prejudice, is met with even in Mr. Stuart Mill.

We are still far from knowing completely the properties of ether, and yet, as Thomson remarked, "We know it better in certain respects than any other substance." The imperfect knowledge of ordinary matter keeps us also in a certain measure from becoming familiar with ether. It is especially ether imprisoned in bodies that bothers us the most. The free ether of space is probably the simplest form of matter.

Our knowledge of ether was condemned to remain very slight as long as it had as an only source the phenomena of radiation. The same idea of the ethereal wave has been, likewise, too narrowly defined in Fresnel's theory of light. Of this idea (which might be extended if other considerations require) we keep the principal features—the periodicity and the transversal character of the vibrations.

"If ether exists," says Faraday, "it must have still other functions than that of the transmission of radiations."

What are these functions?

Under the name of "electricity," or more generally, "electromagnetism," we embrace all the rest, so to speak, of physics, all the domain of the different transformations of energy, of which the order and succession cannot be explained by the properties of ponderable matter nor by the radiant energy of ether. But here it is necessary to make a distinction between the visible and the inner and hidden side of the phenomena. When we make electromagnetic experiments, when we see in action a telegraph or a dynamo, we have before us a series of phenomena which individually are known to us.

We notice certain motions of bodies, a development of light or heat, and certain chemical reactions. In all these, taken separately, there is nothing "electrical," and we might reproduce them as well by some other means without the aid of this "electricity." But the succession of these phenomena, the reciprocal evolution, present themselves in these experiments under such a form that we are compelled to recognize behind these phenomena the presence of certain transitory forms of energy; as the action of a ray of light has led us to the establishment of the existence of waves of ether. But while in luminous waves, a particular organ—the eye—has aided us to observe the radiating energy, no particular sensation reveals to us this form of energy which hides itself behind electrical and magnetic phenomena.

What we notice, what we analyze, are the results, the products of the destruction of this kind of energy. We shall see later what restrictions it is necessary to put on these words. In studying closely this mysterious collection of transformations of energy, to which we give the name of "electricity," we find at the bottom two transitory forms which we call: one, electric energy, the other, magnetic energy. They are bound together in a quite complcated manner. In a medium containing immovable bodies charged with invariable quantities of electricity, electric or electrostatic forces appear.

We consider, since Ampere, magnets as systems of elementary currents. Electrostatics was first known to us and was the object of our favorite researches. The interpretation of these phenomena seemed easy, but under the influence of the immortal pound of Newton it took the form of the theory of universal gravitation. In these two branches they accepted as a basis instantaneous forces acting at a distance. The very law of the action of these forces recalled Newton's law of gravitation. But it was thought necessary to attribute these forces to fluids of their own kind—to electric fluids residing on the interior of ordinary matter, which were able to move themselves through matter with more or less ease under the influence of electric forces. They explained in the same manner purely magnetic phenomena up to the time when Oersted and Ampere combined them in the theory of the electric current. Steven Gray first observed, in 1729, that electricity could spread itself, could flow, so to speak, in conductors, and so he divided bodies into conductors and insulators. The first year of this century (1800) Volta called attention to a powerful source of a continued current in a galvanic battery. Ohm gave us a theory on constant currents in a conducting circuit, guiding himself by the analogy to currents of heat.

Oersted, Ampere (1820) and Faraday (1831) discovered the exterior actions of the current—electromagnetism—using the restricted meaning of the word.

Faraday's induction currents promised to furnish valuable technical applications; we use them now in our dynamos.

Little by little a complicated idea of the functions of the current took the place of the poor scheme of electrostatic phenomena. These were the functions of the current which produce transformations of energy and which are bound in our minds with the idea of electricity.

Even in the greater part of electrostatic experiments (movements of light bodies, etc.) we have, properly speaking, phenomena of the electric current. The old theory was powerless to explain the properties of the electromagnetic field.

It was difficult to localize the energy of a current, to indicate the centres of the acting forces. The simple law of "the square of the distance" did not embrace all the phenomena, and attempts to complete this (Weber's) law did not inspire much confidence on account of their odd and too complicated form. The idea that insulating bodies did not take part in electrical phenomena could not obtain after Faraday's experiments; instantaneous action at a distance became more and more doubtful, and there was no hope of proving the materiality of electricity.

Everything indicated that it was necessary to view the question otherwise. Faraday followed for a long time the idea that one must concentrate one's attention, not on the "conductors," but on the surrounding medium which he called "dielectric."

(To be continued.)

* Translated from the French by Lieut. Wm. W. Harts, Corps of Engineers, U. S. A.

Suggestions for Metering Devices.—11.*

BY S D. MOTT.

In article I. on suggestions in metering instruments of inexpensive construction and economical operation I illustrated in diagram a meter for measuring alternating commercial currents by exalting or transforming them to a static state and then measuring them, which I called a static meter. The instrument shown in Fig. 1 is an amperian meter and has its basis of operation founded in electro-dynamic laws. When the distinguished philosopher Ampere in 1821 promulgated that branch of electrical science which treats of the action of electric currents on one another and on themselves or on magnets, called the laws of electro-dynamics, he gave to the world the foundation principle of operation of all induction motors, using either continuous or alternating currents, in use at the present time.

It would appear as though there were a difference which distinguishes these two forms of electromotive devices. With the continuous current motor the torque or pull is seemingly due to attraction, while with the alternating motor the pull appears to be due to repulsions. There are arrangements, however, as in the present instance, by which these dual forces can be made to act conjointly.

The part of electro-dynamics with which we have to deal here is the law of angular currents, considered in connection with Ampere's theory of magnetism, as follows:

1. Two rectilinear currents, the direction of which forms an angle with each other, attract one another when both approach, or recede from the apex of the angle.

2. They repel one another if one approaches and the other recedes from the apex of the angle.

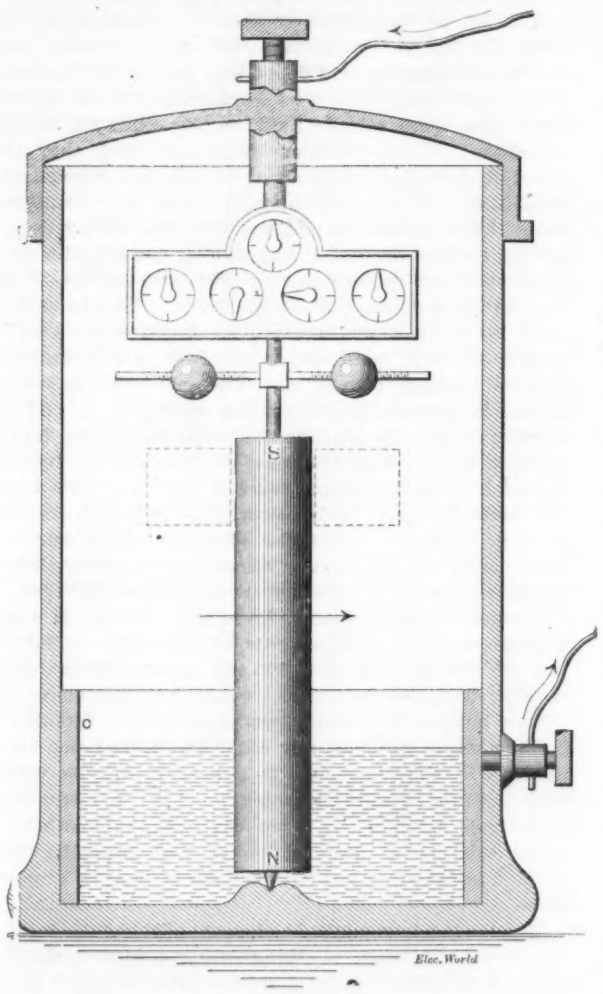


FIG. 1.

Each particle or magnetic element is regarded as constituting a voltaic circuit, and a magnet is made up of an assemblage of parallel filaments, each of which is made up of a series of particles, round which electric currents are circulating in the same direction with reference to the axis of the filament, and moving in planes perpendicular to that axis.

In unmagnetized iron the electricity is supposed to be in a latent state. In a magnetized bar of iron, that extremity of the magnetic filament in which, when looked at end on, the current is moving in the opposite direction to the hands of a watch, has the properties of a N pole, and vice versa.

Fig. 1 is a receptacle made of insulating material into which is introduced, in a vertical position, a fixed mechanical revolution counter, a magnet, free to revolve on its axis, supported in frictionless centres, and arranged so that it will communicate its motion to the direct reading mechanism. The two balls are for calibrating adjustments, and the dotted lines indicate the position of a solenoidal coil to energize the cylindrical magnet in case soft iron instead of steel, permanently magnetized, is used. In the bottom of the apparatus is a conducting medium, which may be mercury or other form of liquid conductors, through which the current to be measured flows in radiating lines from the magnet to the surrounding cylinder c, and thence to the exit binding post on the right. When the magnet is set up and the current is flowing through the meter, the magnet will rotate on its axial line in the direction of the hands of a clock, i. e., to the right, when viewed from the bottom or N end of the magnet, and the speed of revolution will be dependent on the magnet's power and the strength of the current, so that when properly constituted the movement in the meter will be proportional to the strength of the energizing current.

To insure an equalized radiation of current from mag-

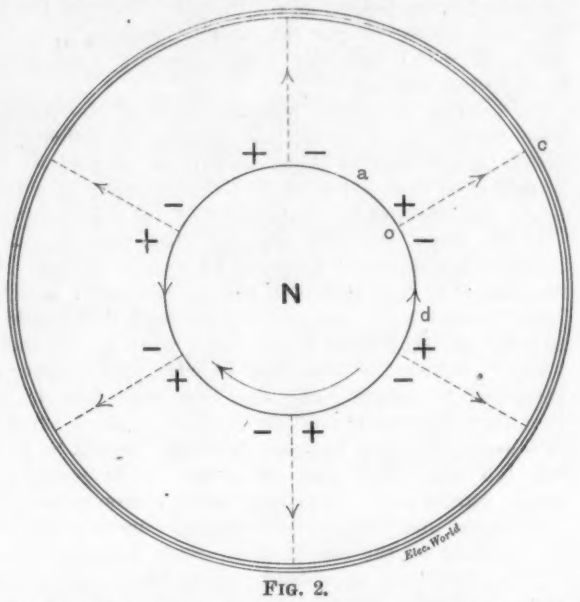


FIG. 2.

net to collector several exit terminals may be arranged around the circumference of collector c, or the same results may be attained by placing collector c in an eccentric position relative to the magnet, in order that all the paths of current from the magnet to the collector c may be of equal resistance.

The explanation of this phenomenon will be found in the mutual mechanical actions of the outflowing currents, and the amperian currents circulating around the magnet, which will be readily understood by inspection of diagrams Figs. 2 and 3, keeping in mind at the same time the laws set forth above.

Referring to Fig. 2 the inner circle represents the circumferential line of north end of magnet, the points of beginning of the radiating sub-divisions of the voltaic current to be measured. The outer circle shows the collector of these currents and their path of exit from the instrument. The arrow heads on fine line of inner circle show the direction of amperian currents around the magnet, those on radiating dotted lines show the voltaic currents to be measured, and the curved arrow the direction of motion of magnet N on its axis.

Let d a and b c, Fig. 3, be two currents crossing at the point o; there will be attraction between the parts b o and d o, because the currents are both converging toward o; and also between o a and o c, because they are diverging from that point; but there will be repulsion between d o and o c, and also between b o and o a, because while b o and d o are approaching the point o, o a and o

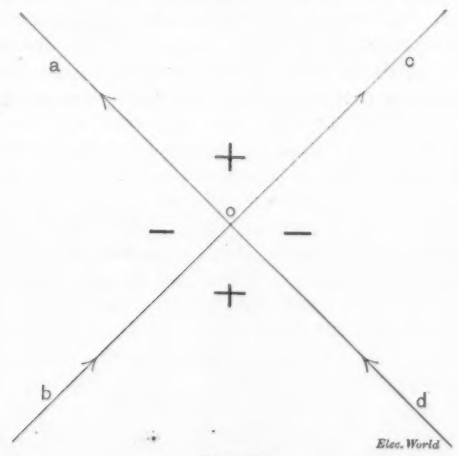


FIG. 3.

c are receding from it. From which it follows the two angular currents tend to parallelism and would coincide in a vertical line, when left to free movement.

By applying this explanation to Fig. 2 it will be observed there are dual forces—attraction and repulsion, as indicated by the plus and minus signs—acting together at an infinite number of points to give the magnet a rotary motion in the direction shown by the curved arrow; which is continuous so long as the current flows and proportional to the current strength.

Experiments in Electric and Magnetic Fields, Constant and Varying.*

BY E. C. RIMINGTON AND WYTHE SMITH.

The object the authors have in bringing these phenomena before the Society is not to establish any new theory, nor to show imperfections in present theories, but to exhibit experiments which help the actions taking place in a dielectric under stress to be more easily grasped.

The experiments are divided into two sets: (1) Performed in varying electric fields. (2) Performed in varying magnetic fields. Although these two fields cannot exist separately, their effects are isolated.

* A paper read at a meeting of the Physical Society (London).

SET. 1.—*Constant Electric Field.*—A constant electric field was produced by two charged metal discs + and —, each of which was stuck on the outside of a glass plate (Fig 1). The object of the glass plates was to prevent brush discharges between objects placed in the field and the plates.

Fig 1, *a b*, represents a partially exhausted electrodeless tube, placed in the uniform electric field. In the position shown the tube is at a uniform potential. Now let it rotate in the direction of the arrow; the potential of *a* will fall and *b* rise until the potential difference between the ends is sufficient to break down the tubes. There will then be a displacement current equalizing the potential, during the continuance of which the tube will glow. On rotating

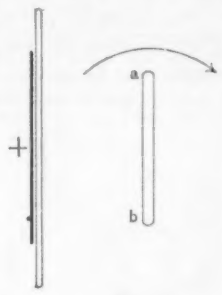


FIG. 1.

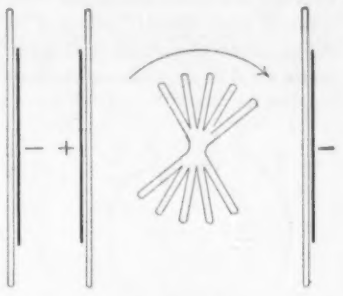


FIG. 2.

still further a similar action will take place. The effect of these actions is to produce a double fan-shaped set of images, as shown in Fig. 2. The number of images in the fan depends on the intensity of the field. This phenomenon is intensified by constricting the middle part of the tube.

In designing the tubes for these experiments, care was taken to have the point where they were connected to the pump in such a position that there was no tendency for discharge to take place at these points when in use. The tubes used in this experiment are shown in Fig. 3 (*a*, *b*, *c* and *d*). The stem was used to connect them to the whirling motor. The surfaces of these tubes should be fairly clean and dry, and it is advisable with a new tube, or one left unused for some time, to excite it between the knobs of an influence machine. In the double fan-shaped set of images one end will be seen to be brighter than the other,

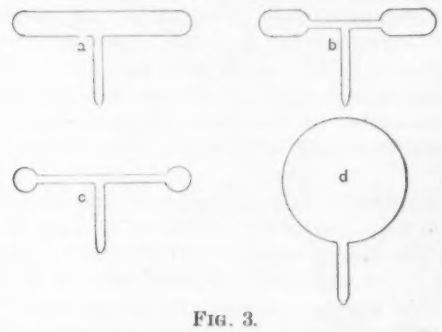


FIG. 3.

the current passing from the dull end to the bright end. Not only is this effect visible with a straight tube, but on rotating an exhausted bulb in the field a stationary luminous region will be seen.

Varying Electric Field.—Instead of rotating the tube a similar effect is produced by varying the field in which the tube is placed. The tube should be placed with its longer axis in the direction of the lines of force. The plates in this case may either be charged and discharged by influence machine and dischargers, the latter sparking, or by an induction coil, with or without sparking. When an induction coil is used, very long tubes will glow when brought near.

SET 2.—*Magnetic Field.*—The authors were of the opinion that, by taking advantage of the action of the Geissler tube, one might show Hertzian phenomena to fairly large audi-

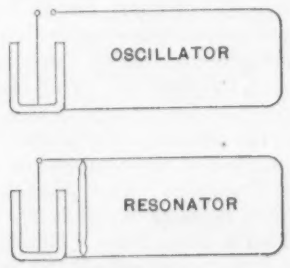


FIG. 4.

ences They, therefore, substituted a Geissler tube for the spark gap in the resonator. This was very successful with a Leyden jar oscillator. The oscillator and resonator consisted of two similar small Leyden jars for capacity, and a single convolution of thick copper wire for the conductor circuit. The Geissler tube was placed as a shunt to part of the conductor circuit of the resonator (see Fig. 4).

But although they designed special tubes, they were unable to get good results with the ordinary forms of Hertz oscillator and resonator. They next made a resonator of the following form: Two metal plates, *a* and *b* (Fig. 5), give capacity and the wire self induction. An electrodeless exhausted tube was placed as dielectric between the plates. When a fairly large Hertz oscillator was used this tube glowed brightly, even when taken to considerable distances.

Glow Produced in Varying Magnetic Fields.—Instead of, as in the last set of experiments, having a secondary com-

* For the first section of this article see THE ELECTRICAL WORLD of Jan. 14, 1893, page 26.

posed partly of a metallic conductor and partly vacuum tube, the whole circuit may be composed of rarefied gas. It is evident that, in order to generate a current in such a circuit, a large induced E. M. F. would be required; this would have necessitated either a very strong magnetic field, or one which changed very rapidly. The former was out of the question, the latter was obtained by taking advantage of the phenomenon of oscillatory discharge in the following manner:

P (Fig. 6), a primary consisting of a very few turns of gutta-percha covered wire, was placed in a Leyden jar circuit, as shown. As a secondary an exhausted bulb, or annular tube, was placed near *P*. On sparks passing at *D*, a bright ring of light appeared in the secondary. In the actual experiments a metallic secondary *S* was also wound with *P* and exactly similar to it. On short circuiting *S* the induced current in this circuit will weaken the magnetic field so as to completely extinguish the Geissler sec-

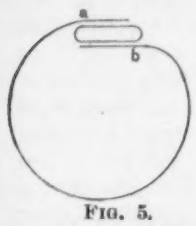


Fig. 5.

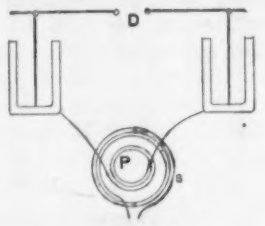


Fig. 6.

ondary. If *S* is connected to a third coil, this coil will behave in a similar manner to *P* with weaker effects; *P* and *S* in this case form a one to one transformer. The wire of the coil *P* is itself luminous when *S* is open; short-circuiting *S* will stop this effect.

In the discussion which followed, Mr. Swinburne thought some of the effects shown were not Hertzian, but merely cases of ordinary mutual induction. He inquired whether the vacuum tubes would still glow if the Leyden jars were removed from the so-called resonating circuits. He was also of the opinion that in the magnetic experiments the surfaces of the bulbs, and not the enclosed gases, took the charges. Mr. Watson asked if the authors had tried screening off the long waves by a wet cloth. If the effects still existed, this would prove that they were Hertzian. Mr. Blakesley wished to know if the images of the rotating tubes were at equal angular distances. Mr. Smith pointed out that these distances were not equal, but corresponded to equal changes of potential. Prof. Ayrton remarked that the only cases where the materials of the bulbs, tubes, etc., did not influence the results were those in which discharges were produced by varying magnetic fields.

Mr. Rimington, in replying, said that the explanation why, in the experiments performed in varying magnetic fields, the bright parts of the luminous discharges were near the wire, appeared to be, that the E. M. F. was greatest in these places. Although he had not tried the experiment suggested by Mr. Swinburne, of taking off the Leyden jar, he felt sure that doing so would stop the glow.

Experiments with High Frequency Electrical Discharges.

BY A. A. CAMPBELL SWINTON.

The author has succeeded in passing through his body from hand to hand sufficient electricity to bring the filament of an ordinary 5 c. p. 100 volt incandescent lamp very nearly to full incandescence, or to bring the filament of a 32 c. p. 100 volt lamp to full redness. Practically no sensation was experienced.

The apparatus employed consisted of a large "Apps" induction coil capable of giving 10-in. sparks, supplied with current through the ordinary vibrating contact breaker and a resistance consisting of eight 50 c. p. lamps in parallel, from a 105 volt continuous current supply. To the positive and negative terminals of the secondary of the induction coil were connected respectively the inside and outside coatings of three half-gallon Leyden jars, connected in parallel. The disruptive discharge of these jars across an air gap of about a quarter of an inch excited the primary of a simple form of high frequency coil, similar to those employed by Mr. Tesla and Prof. Elihu Thomson. The secondary of this coil consisted of 500 turns of No 26 S. W. G. cotton covered wire, wound on a paper tube. Outside this paper tube was a glass tube, upon which the primary, consisting of 10 turns of three No. 16 gutta percha covered wires, in parallel, were wound. The whole coil was immersed in resin oil contained in a wooden trough. The ends of the secondary were connected through small glass tubes, also filled with oil, to brass balls.

On approaching the hand to one of the balls forming the terminals of the oil coil, sparks shoot out from the brush discharge which surrounds it. If the spark is taken on the skin a sharp prick is felt, but on approaching the terminal or touching it with a piece of metal grasped in the hand, or after grasping the terminal itself, practically no appreciable sensation is felt. If the terminal is grasped in this manner with the right hand, sparks will shoot out from the left hand, or, indeed, from any other portion of the body, if brought into proximity with another person, a piece of metal, the gas or water pipes, or any conducting body. In the experiment referred to the incandescent lamp was hung by one terminal on a wire connected to earth, and connection was made between the other lamp terminal and the coil through the two arms and body by the right hand being brought into contact with one terminal of the oil coil, and a piece of metal grasped in the left hand being approached to the free terminal of the lamp. At the first approach the bulb of the lamp became filled with phosphorescent light, but on reducing the distance between the metal in the left hand and the free lamp terminal, sparks shot out between them and the filament at once became incandescent, the incandescence increasing very nearly to the full normal amount when the piece of metal and the lamp terminal were finally brought into contact.

To produce a similar incandescence of the filament with continuous or alternating currents of ordinary frequency would require about one-fifth of an ampere, and at first sight it would seem that this quantity of current might pass through the arms and body of the operator.

It has been generally assumed that high frequency currents are rendered harmless by reason of their high frequency; in fact, that high frequency renders harmless to the human body currents of a strength that would be painful and dangerous, if not fatal, were the frequency lower. The author is inclined to think that another explanation is possible and that the true fact is, not that high frequency renders harmless a given strength of current that with ordinary frequency would be harmful, but that with high frequency it is possible to obtain effects with exceedingly small currents that with continuous and ordinary alternating currents can only be obtained by the use of those much larger.

This hypothesis is probably applicable to many other high frequency effects, but as applied to the above mentioned experiment it is simply this: The lamp filament having a certain definite resistance with continuous or ordinary alternating currents which pass uniformly or nearly so through the section of the filament, a certain amperage of current is necessary to produce the number of watts required to raise the filament to incandescence. With the high frequency currents on the other hand, as is well understood, the current travels chiefly on the outer surface of the filament, little or none passing through the central portion. The current is, in fact, merely skin deep. The virtual resistance is therefore very high, as only an extremely small portion of the sectional area of the filament acts as a conductor. There is an ample sufficiency of volts, and, though the current is very minute, there is a sufficient expenditure of watts to raise the filament to incandescence. The lamp, in fact, ceases to be a 100-volt lamp and becomes, it may well be, a 100,000-volt lamp. As confirming this hypothesis, it should be mentioned that while the filament was incandescent sparks passed between the lamp terminals, which were at some distance apart, this being evidence that there was a difference of potential amounting at least to thousands of volts between the two ends of the filament. Returning to the experiments, several other curious results were obtained. If instead of connecting the lamp to the coil through the human frame, a wire was used, the filament became much brighter than in the previous experiment. In fact, it gave considerably above its normal candle power. From this it was evident that the human body offered considerable opposition of some description to the passage of the electricity. In order to form some idea of the amount of this opposition the body was again inserted in the circuit between the coil and the lamp as previously, and the thumbs of the two hands brought near together. Sparks about one-quarter of an inch in length were found to pass between them, evidencing that the two hands of the operator had a difference of potential between them apparently equal to some thousands of volts. When the sparks passed between the hands, or when the wrists were brought into contact, so, as it were, to short circuit to some extent the resistance of the arms and body, the filament became very appreciably brighter. It should be mentioned that when the sparks were allowed to pass between the hands very perceptible shocks were felt in the wrists.

Another experiment was to connect one lamp terminal by a wire to the coil, connect the other lamp to earth, and short circuit the lamp through the body by grasping the coil terminal with one hand and a piece of metal connected to earth with the other. The effect of so doing was to reduce the incandescence of the filament to rather less than one-half of its normal amount, half of the available current going apparently through the lamp, the other half through the body.

With the lamp terminal connected to the coil, it was found unnecessary to conect the other lamp terminal to earth to produce incandescence, all that was necessary being to touch this lamp terminal with a piece of metal held in the hand. That the incandescence of the filament produced under these conditions was due to the electrostatic capacity of the operator, and not to his forming a connection to earth, was evidenced by the fact that it made no perceptible difference whether he stood on the floor or on an insulated stool.

In all the above experiments the second terminal of the oil coil was free and not connected to anything. It was, however, found that the effect of a second operator touching this terminal, or of connecting it by wire to earth, was to diminish the incandescence of the lamp filament. It was also found that the filament incandesced to a greater degree of brightness when connected as above between one terminal of the coil and earth than when it was directly connected between the two terminals of the coil. This seems to show that capacity has much to do with the results obtained.

It should also be mentioned that in some of the experiments there was a decided tendency for the filament to vibrate in unison with the contact breaker of the induction coil. In fact, in some cases the amplitude of vibration was sufficient to cause the end of the filament to beat against the glass of the lamp bulb.

Electrical Recording Meters.*

BY CARYL D. HASKINS.

After a discussion of what unit was the most appropriate for the measurement of electrical power, and arriving at the conclusion that the watt was for many reasons more rational than the ampere-hour, Mr. Haskins took up the various classes of meters now in use, and discussed their inherent good and bad features. Beginning with the chemical meter, he said:

"The chemical meter is obviously capable of giving most accurate results; in fact, with proper manipulation, it is very doubtful whether any measuring device which has up to to-day been designed, could more correctly sum up passing power. An electroplating bath, in its meter form as generally used, does not, however, give a dial indication, and the consumers ask for a dial indication almost invariably, unless they have already become thoroughly familiarized with Edison meters as used by many large Edison stations. The attempts to render these self-registering by dial indication have usually introduced the element of friction to such an extent as to largely destroy their accuracy.

"The second group of meters under this classification brings us to the thermo-meters, a typical group containing a few meters of more or less pronounced merit.

"Those thermo-meters depending upon volatilization of a fluid generally have two or more sealed bulbs partly filled with some volatile fluid, as, for example, naphtha or ether. When two such bulbs are used, they have generally been mounted on a walking-beam mechanism combined with a pole changer, each bulb containing some kind of a rheostat or heat developing device dependent for its heat on the current passing through the meter, the two bulbs communicating with one another. The rheostat in but one bulb is in circuit. The heat developed in the rheostat in circuit volatilizes more or less rapidly the fluid contained in this bulb, according to the current passing through it. The gas developed either passes in gaseous form into the second bulb and condenses, or else, as is more common, forces the fluid remaining by the simple increase of pressure into bulb No. 2, which at once becomes heavier and causes its end of the beam to fall. To be successful such a device must be very sensitive, and to be sensitive the construction must be of a more or less expensive character and so delicate as to be to a greater or less degree prohibitive."

Discussing clock meters, he said: "There is almost endless variety of instruments of this kind. They are not all electricity meters by any means; some are recording voltmeters, others recording ammeters, and others have still different purposes. The familiar recording steam gauge is only a modification of this instrument. In these a paper is almost invariably rotated over a drum, sometimes being fixed to the drum, and sometimes being drawn from one drum to another, the paper moving at uniform speed, and generally being divided into hours or other fractions of time by abscissae lines.

"One of the best methods of accomplishing the registration—perhaps, when all things are considered, the very best—is to attach to the pointer of the indicator a steel point or needle with an iron armature mounted in the form of a spring or in some similar manner. By placing an electromagent behind the paper to be marked, and sending through this magnet an electrical impulse at fixed periods, of say, one, two or five minutes, the pointer is drawn sharply down to the paper, puncturing it, and is immediately released by the cessation of energizing current in the electromagnet. Thus the paper, when removed, will have a continuous marking of punctures tantamount to a curved line. This device presents practically no friction, and is more or less simple and easy to carry out. The make-and-break necessary for the electromagnet is easily actuated by the clock movements. But we may say of these forms, as well as of the forms of clock meter which are to follow, that there is one serious objection to them all—they have to be wound up, which is certainly a fault.

"All of these instruments being curve-drawing meters, they cannot properly be considered as the thoroughly commercial article, which the successful electric meter must be. For, I think I am safe in assuming that to be successful the meter of to-day positively must have a direct reading dial, equally available for the consumer and supplier.

"This brings us to a second form of clock meter of a preferable character. This class comprises those meters whose clock mechanism is accelerated or retarded by the strength of the current passing through them. There are several methods of accomplishing this, all of which

* Abstract of a paper read before the Am. Inst. Electrical Engineers, Jan. 17, 1893.

apply the influence of the current to the pendulum of the clock.

"The most successful and probably the best form of meter of this kind consists of two clocks with a differential gear between. One of these clocks runs at a constant speed, the speed of the other being governed by the circuit to be measured; at times by a shunt pressure coil forming an armature, and a fixed series coil forming a field, or again by a horseshoe magnet pendent from the pendulum and vibrating back and forth above two coils in series with the lamps, the former being a wattmeter and the latter an ammeter. When nothing is passing through the meter, the speed of both clocks is the same, and the differential gear does not move; but when lamps are turned on, and the regulating device begins to act, one clock is accelerated or retarded according as the principle may be applied, and the difference between the constant speed clock and the varying speed clock indicates the consumption in directly read units.

"I can safely say that this is an excellent meter, but is obviously open to the same objection as are other clock meters, since there are two clocks, and the presence of the differential gear requires very nice adjustment between the two.

"I might say, however, that the Aron meter, the typical meter of this type, proved itself so accurate at the recent meter competition in Paris that it succeeded in dividing the first prize of 10,000 francs and a gold medal with the Thomson recording wattmeter, the principle of which we shall consider later. Your attention may be directed to the fact that the Aron meter is a watt-hour indicator, something unusual, for almost everything considered up to the present point has been typically an ammeter or a modification of an ammeter.

"A novel form of cone ammeter, still a clock meter, has been introduced. It consists of a conical drum, shaped like the bullet of an ordinary rifle, and some four or six inches in diameter at the base, rotated at a constant speed by a clock mechanism beneath it; a spool of thread is placed upon a pin a foot or so removed from the drum; the thread from the spool is attached to the drum, which should be covered by some felt-like material; the thread passes through an eye or ring, which, in its turn, is attached to an indicating mechanism. It is apparent that the indicator will raise and lower the spring according to the amount of current or energy passing. Since the drum rotates at a regular speed, the thread will be wound onto the drum, and the point where it is wound on will depend on the position of the indicator. Thus, if the load is very small, the indicator will be at its highest point, and the thread will be wound around the smallest diameter of the drum. As the load increases the indicator will be depressed and the thread will be wound on a greater diameter of the drum. The inspector of meters, on his monthly visit, removes the thread which has been wound onto the drum, measures it on a yard stick, and ascertains perhaps that the consumer has used 15 yards of electricity. This is certainly reducing things to a very practical standpoint."

Of motor meters he said: "In the majority of cases motor meters have been designed for alternating circuits, and these, again, naturally divide themselves into two classes, those actuated by inductive principles, and those whose motive powers act direct, and which are similar in character to the electric motor. Of the first class, there is a large number, designed of course for alternating circuits.

"These are almost exclusively of two forms—the wound and the unwound armature types. But few, if any, of the former are in practical use, though several have, I believe, shown very fair results. As a rule, they consist of a field formed of a coil or coils in series with the lamps, and a small drum or other closed circuit armature, preferably without iron, whose commutator is short-circuited across by directly connected brushes or other similar means. This meter will record with considerable accuracy, but in the presence of better and simpler plans it has not met with general favor.

"The other class of inductive meters consists, in general, of a coil or coils, in series with the lamps forming the primary. A short-circuited coil of low resistance within and at angle to this forms the secondary, and within this again is a more or less solid metal armature, of disc, drum or other shape generally, wholly or in part of iron, and mounted on a carefully balanced shaft, which, on rotating, actuates the recording dial.

"Meters of this construction, while highly practical and decidedly useful, are scarcely all that could be desired, for several reasons, all of which tend to introduce errors. In the first place, their construction and principle prohibit entire accuracy on very low readings. This is quite largely due to the fact that nothing is present to balance friction.

"The remaining class of motor meters embraces those with a series field and shunt armature. These are somewhat of a departure from the others, since they are not current meters, but power or wattmeters. Their construction is in all cases quite similar to an ordinary shunt motor, the conditions of field and armature being reversed.

"The field is in series with the lamps; the armature, which is of high pressure, and generally of Siemens' construction, with a commutator of a few segments, is placed 'in shunt across the line,' the shunt being taken off beyond the field coils. An outside resistance is placed in this shunt circuit, to reduce the current in the armature to the necessary small quantity and to prevent any appreciable waste across the line.

"Motor meters, as a class, rotate far more rapidly than is allowable in practice. It has been found necessary, therefore, to introduce a 'drag,' or resistance to rotation, to slow the meter to a reasonable speed. This has been done in several ways; perhaps the most common method being to attach to the shaft a number of air fans. These are quite largely used, and with fair success. The resistance of an air fan to rotation is approximately proportional to the square of the speed. Therefore this device is only fitted for combination with such meters as have a torque increasing with the square of the current. But since the torque of such meters does not quite reach the square, the retarding effect increases rather too rapidly and has a tendency, though not always pronounced, to cause the speed of the meter to fall off proportionately on high loads.

"Another method of drag, which has been used with some success, is the rotation of a small fan in a liquid, a method perhaps rather better than the previous one, since resistance to rotation falls below the square of the speed when the liquid itself begins to rotate. Much depends in this case on the shape of the receptacle containing the fluid.

"A third method, certainly by far the best, consists in rotating a small inefficient dynamo, generally a mere disc, turning between permanent or electro-magnets. This resistance is of course directly proportional to the speed, and therefore to the torque, being indeed the machine reversed. By applying this drag, friction is again the only difficulty to contend with.

"One other important point in connection with the drag and the friction we must not neglect. The greater the drag (commensurate, of course, with sufficient speed) the smaller the proportion of friction to the total load will be, and the greater the accuracy of the instrument's registration.

"To sum up, then, it would seem that the most practical and useful meter, according to our present light, would be a motor meter of other than inductive type—preferably an energy rather than a current meter—with some force to balance friction, with a drag which is directly proportional to the speed, and which will be comparatively heavy, making the irregular friction as small a portion of the load as possible.

"With all these features properly worked out and applied, there can be no reason why a meter should not be accurate, efficient, comparatively cheap and thoroughly able to take care of itself without undue attention."

The reading of the paper was followed by a considerable discussion by members of the Institute on the merits of some types of meters, as also the proper unit to be adopted in the scales employed.

Experimental Researches on Alternate Current Transformers.—IV.*

BY DR. J. A. FLEMING.

13. It is desirable to make one or two remarks about each transformer, and draw some general conclusions.

FERRANTI TRANSFORMER, 1885 TYPE, 5 H. P. (TABLES IX. AND X.)

[Table IX. shows the following: Secondary volts, 100. Frequency, 81.6 periods. Average final temperature, 212 degrees Fahr. Volts on primary circuit, 2,400. Primary circuit resistance = 12.50 ohms at 212 degrees Fahr. Secondary circuit resistance = 0.0252 ohm at 212 degrees Fahr. The primary ampères rose from .332 to 1.89; the secondary from 0 to 38.78, and the secondary volts fell from 100.9 to 99.1. The total power taken up in the transformer rose from 538 to 636. Table X. shows that the primary ampères rose from 0.329 to 1.9; the secondary from 0 to 39.19. The primary copper losses rose from 1.3 to 45.2; the secondary from 0 to 38.7. The real primary watts rose from 538 to 4,580, and the apparent primary watts from 790 to 4,555. The power factor rose from .68 to 1.]

It is obvious that this transformer is, in comparison with modern ones of the same size, very wasteful of energy in transformation. But we must bear in mind that in 1885 little or none of our present knowledge about iron core energy losses existed, and it is not to be wondered at that its design is imperfect, according to modern views. The immense core loss of 549 watts (540 by three-voltmeter method) makes it possess a low efficiency at all loads, and gives it a flat efficiency curve. Its small copper losses, however, make it remarkably good in regulation, it having only 2.4 per cent. of total secondary drop. It is hardly necessary to say that Mr. Ferranti's present type of transformer is a vast improvement on these, and holds its own with the best now made.

FERRANTI TRANSFORMER, 1885 TYPE, 5 H. P., REWOUND. (TABLES XI. AND XII.)

[Table XI. shows the following: Secondary volts, 100. Frequency, 81.6 periods. Average final temperature of transformer, 150 degrees Fahr. Volts on primary circuit, 2,400. Primary circuit resistance = 29.80 ohms at 150 degrees Fahr. Secondary circuit resistance = 0.057 ohm at 150 degrees Fahr. The primary ampères rose from 0.11 to 1.741, the secondary from 0 to 39.65, and the secondary volts fell from 102.7 to 98.4. The total power taken up in the transformer varied between 235 and 399. Table XII. shows the following: Secondary volts at no load, 102.7. The primary ampères rose from 0.11 to 1.741, the secondary from 0 to 39.65. The real primary watts rose from 235 to 4,301, and the apparent primary watts from 264 to 4,178. The primary copper losses rose from 0 to 90, and the secondary copper losses from 0 to 89.5. The power factor rose from 0.98 to 1.03.]

The effect of doubling the length of both the primary and secondary circuits is shown in the curves of this transformer. The total internal losses are halved, but the copper losses and "secondary drop" about doubled.

FERRANTI TRANSFORMERS, 1892 TYPE, 15 AND 20 H. P. (TABLES XV. XVI., XVII., XVIII., XIX., XX.)

[Table XV. shows the following: Power, 15 h. p. Secondary volts, 100. Frequency, 81.6 periods. Volts on primary circuit, 2,400. Primary circuit resistance = 6.45 ohms. Secondary circuit resistance = 0.0134 ohm. The primary ampères rose from 0.076 to 3.715, when no further readings were recorded. The secondary current rose from 0 to 114.63, and the secondary volts fell from 100.4 to 97. The total power taken up in the transformer varied between 149 and 570. Table XVI. shows the following: 15 h. p. Primary volts, 3,400. Secondary volts at no load, 100.4. The primary ampères rose from 0.076 to 4.762, the secondary rose from 0 to 112.89. The primary copper losses rose from 0 to 146.4, and the secondary from 0 to 171. The real primary watts rose from 149 to 11,496, and the apparent primary watts from 188 to 11,429. The power factor varied

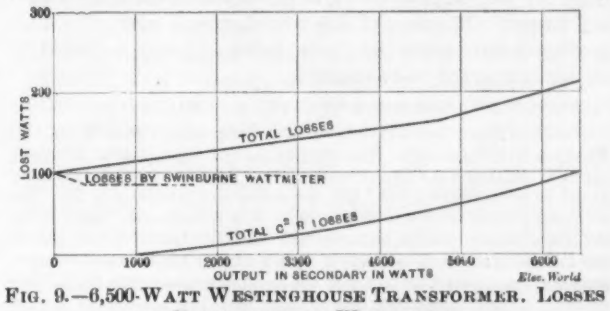


FIG. 9.—6,500-WATT WESTINGHOUSE TRANSFORMER. LOSSES BY DYNAMOMETER WATTMETER.

between 0.82 and 1.05. Table XVII. shows the following: Transformer rewound. 15 h. p. Secondary volts = 100. Frequency, 82.5 periods. Volts on primary, 2,400. Primary circuit resistance = 3.77 ohms. Secondary circuit resistance = 0.0092 ohm. The primary ampères rose from 0.103 to 4.837, the secondary from 0 to 113.85. The secondary volts fell from 100 to 97.8. The total power taken up in the transformer rose from 229 to 607 watts. Table XVIII. shows the following: 15 h. p. Primary volts, 2,400. Secondary volts at no load = 100.0. The primary ampères rose from 0.103 to 4.837, the secondary from 0 to 113.85. The primary copper losses rose to 88.1, and the secondary from 0 to 119. The real primary watts rose from 229 to 11,742 and the apparent primary watts rose from 247 to 11,609. The power factor varied between 0.93 and 1.01. Table XIX. shows the following: Power, 20 h. p. Secondary volts, 100. Frequency, 82.7 periods. Average final temperature, 98 Fahr. Volts on primary, 2,400. Primary circuit resistance = 2.75 ohms at 98 degrees Fahr. Secondary circuit resistance = 0.0061 ohm at 98 degrees Fahr. The primary ampères rose from 0.112 to 6.5, the secondary from 0 to 151.44. The secondary volts varied between 100 and 97.9. The total power taken up in the transformer varied between 210 and 525. Table XX. shows the following: 20 h. p. Primary volts, 2,400 Secondary volts at no load, 100.0. The primary ampères rose from 0 112 to 6.5; the secondary from 0 to 151.44. The primary copper losses rose from 0 to 116, and the secondary from 0 to 138. The real primary watts rose from 230 to 15,322, and the apparent primary watts from 269 to 15,600. The power factor varied between 0.86 and 1.03]

These new transformers of Mr. Ferranti are exceedingly good transformers. The total loss on open circuit of the 20 h. p. is only 1.3 per cent. of the full secondary output. The maximum efficiency is 97.1 per cent. and the efficiency at one-tenth of full load is 85 per cent., while the total secondary drop is only 2.1 per cent.

In two transformers tested there was a difference in the winding which resulted in the total internal loss being greater in one than in the other. In the transformer having the greatest total loss the copper losses (C^2R) are least, and the "secondary drop" diminished, therefore, about 1 per cent. The efficiency curve of all these transformers is very square-shouldered, owing to the high efficiency (about 85 to 87 per cent.) at one-tenth of the full secondary load.

WESTINGHOUSE TRANSFORMER, 6,500 WATTS. (TABLES XIII. AND XIV. FIGS. 9, 10 AND 11.)

[Table XIII. shows the following: Secondary volts, 100. Frequency, 82.5 periods. Average final temperature, 96 degrees Fahr. Volts on primary circuit, 2,400. Primary circuit resistance = 5.95 ohms at 96 degrees Fahr. Secondary circuit resistance = 0.0108 ohm at 96 degrees Fahr. The primary ampères rose from 0.05 to 2 775; the secondary from 0 to 64.748. The secondary volts fell from 101 to 98.6. The total power taken up in the transformer rose from 95 to 214. Table XIV. shows the following: Secondary volts at no load = 101.0

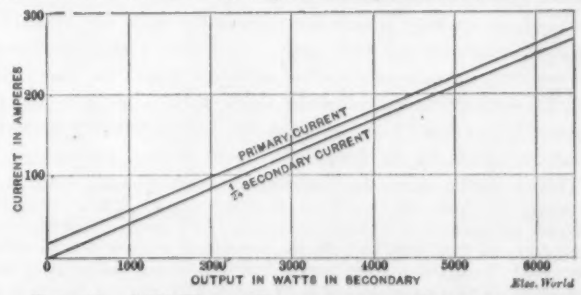


FIG. 10.—6,500-WATT WESTINGHOUSE TRANSFORMER.

The primary ampères rose from 0.05 to 2.775; the secondary from 0 to 64.74. The primary copper losses rose from 0 to 45.8, and the secondary from 0 to 45.3. The real primary watts rose from 95 to 6,598, and the apparent primary watts from 120 to 6,600. The power factor varied between 0.79 and 1.03.]

This transformer was one of the pair tested by Dr. J. Hopkinson by his elegant differential method. His results are recorded in THE ELECTRICAL WORLD, July 16, 1892, p. 40, and July 23, p. 57. Employing a method depending upon the graphic description of the instantaneous curves of current and E. M. F., Dr. Hopkinson deduced the power lost in the transformer at no load, quarter, half, full load. Hence the corresponding efficiencies. The same quantities were given me independently as determined by the manufacturers from tests made at Pittsburgh. These are here collected with my own results for

*Abstract of a paper read before the Institution of Electrical Engineers (London). For the preceding sections see THE ELECTRICAL WORLD, Dec. 24, 1892, p. 413; Jan. 7, 1893, p. 15, and Jan. 21, p. 52.

comparison. Dr. Hopkinson's results are placed in the column marked H, those of the manufacturers in column P, and my own in column F; and it will be seen that we all substantially agree in the values of the quantities measured.

Quantities Measured.	P.	H.	F.
Watts lost at no load	91	114	98
Watts lost at half load	—	149	141
Watts lost at full load	—	236	209
Secondary drop at full load	2%	2.2%	2.4%
Efficiency at half load	96.4	96%	96%
Efficiency at full load	97%	96.9%	96.9%
Total copper losses (C^2R) at full load, in watts	104	—	93

It is clear, therefore, that there is no serious disagreement between us, and that this transformer is a very excellent instrument. Its maximum efficiency is just upon 97 per cent., and its efficiency at one-tenth of full load is nearly 85 per cent.

The loss in power at no load is by my figures 1.46 per cent. (by Dr. Hopkinson's 1.75 per cent.) of the full secondary output. The core of this transformer is made of a high quality of pure steel, the plates being slightly oxidized to insulate them for eddy currents.

MORDEY TRANSFORMER, 6,000-WATT. (TABLES XXI. AND XXII.)

[Table XXI. shows the following: Secondary volts, 50 and 100. Frequency, 82.9 periods. Volts on primary circuit, 2,400. Primary circuit resistance = 7.73 ohms; secondary 0.0163 ohm. The primary ampères rose from 0.076 to 2.668, the secondary from 0 to 61.58. The secondary volts fell from 101.1 to 99.2. The total power taken up in the transformer varied between 148 and 311. Table XXII. shows the following: Secondary volts at no load = 101.1. The primary ampères rose from 0.076 to 2.668; the secondary from 0 to 61.58. The primary copper losses rose from 0 to 55, and the secondary from 0 to 62. The real primary watts rose from 148 to 6,420, and the apparent primary watts rose from 182 to 6,403. The power factor varied between 0.81 and 1.03.]

Two transformers of this size were tested. In one the three-voltmeter method showed the power loss at no load to be 125 watts; in the other the dynamometer wattmeter gave 148 watts. If we take the mean of these results, we get 136 watts as the open-circuit loss. This is 2.27 per cent. of 6,000 watts. We found the "total secondary drop" between no load and full load to be 1.9 per cent. of the voltage at no load.

According to our observations this transformer takes rank as one of the best for regulation, having regard to its size and its open-circuit loss. The maximum total copper

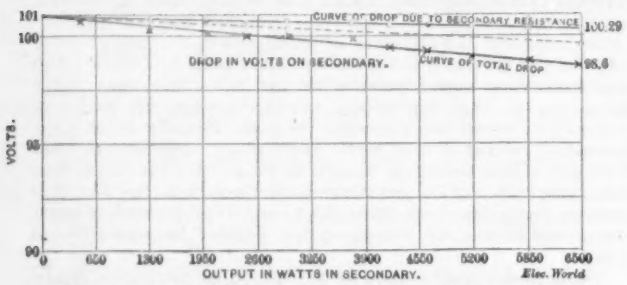


FIG. 11.—6,500-WATT WESTINGHOUSE TRANSFORMER.

loss (C^2R loss) is 117 watts, and the maximum total loss at full load is 311 watts. The maximum efficiency is close to 96 per cent and the efficiency at one-tenth of full load is 80 per cent.

We shall deal more at length presently with the important question of the constancy of the iron losses at all loads, which the observations on this transformer bring out most clearly.

THOMSON-HOUSTON 4,500-WATT TRANSFORMER. (TABLES XXIII. AND XXIV.)

[Table XXIII. shows the following: Secondary volts, 50 and 100. Frequency, 82.1 periods. Average final temperature, 102 degrees Fahr. Volts on primary circuit, 2,400. Primary circuit resistance, 19.68 ohms at 102 degrees Fahr. Secondary, 0.019 ohms at 102 degrees Fahr. The primary ampères rose from 0.083 to 1.96; the secondary from 0 to 46. The secondary volts fell from 99.8 to 96.5. The total power taken up in the transformer varied between 114 and 265. Table XXIV. shows the following: Secondary volts at no load = 99.8. The primary ampères rose from 0.083 to 1.96; the secondary from 0 to 46. The primary copper losses rose from 0 to 76, and the secondary from 0 to 40. The real primary watts rose from 116 to 4,695, and the apparent primary watts from 199 to 4,704. The power factor varied between 0.58 and 1.01.]

There is nothing which here specially calls for remark. The transformer is a very good example of a high efficiency closed iron circuit transformer of small size. At one-tenth of full load the efficiency is 79.1 per cent. The open-circuit loss is only 1.6 per cent. of the total full secondary output.

KAPP 4,000-WATT TRANSFORMER. (TABLES XXV. AND XXVI.)

[Table XXV. shows the following: Secondary volts, 100. Frequency, 82.1 periods. Volts on primary circuit, 2,400. Primary circuit resistance, 11.38 ohms; secondary, 0.024 ohm. The primary ampères rose from 0.145 to 1.750; the secondary from 0 to 40.89. The secondary volts fell from 99 to 97.1. The total power taken up in the transformer rose from 152 to 236. Table XXVI. shows: secondary volts at no load = 99.0. The primary ampères rose from 0.145 to 1.75; the secondary from 0 to 40.89. The primary copper losses rose from 0 to 34.5, and the secondary from 0 to 42. The real primary watts rose from 152 to 4,207, and the apparent primary watts from 348 to 4,200. The power factor varied between 0.61 and 2.01.]

This is a very interesting transformer, having an exceedingly good regulation for such a small size. Its total secondary drop is under 2 per cent. of its secondary voltage at no load, and its open-circuit loss is 2.8 per cent. of full output. It is curious in the rather slow rise of its power factor as the secondary load is increased. More about this will be said presently. The good regulation of the transformer and small "leakage drop" are no doubt due to the effective "sandwiching" of the primary and secondary coils.

SWINBURNE 3,000 WATT "HEDGEHOG," TRANSFORMER. (TABLES XXVII., XXVIII. AND XXIX. FIGS. 12, 13 AND 14.)

[Table XXVII. shows the following: Volts, 100. Frequency, 81.1 periods. Average final temperature, 145 degrees Fahr. Volts on primary circuit, 2,400. Primary circuit resistance = 24.50 ohms at 145 degrees Fahr.; secondary, 0.051 ohm at 145 degrees Fahr. The primary ampères rose from 0.756 to 1.566; the secondary from 0 to 30.2. The secondary volts fell from 101.8 to 0.99. The total power taken up in the transformer varied between 111 and 207. Table XXVIII. shows the following: Volts, 100. Frequency, 82.3 periods. Average final temperature, 145 degrees Fahr. Volts on primary circuit, 2,400. Primary circuit resistance, 24.00 ohms at 145 degrees Fahr.; secondary. 0.051 ohm at 145 degrees Fahr. The primary ampères rose from 0.756 to 1.567; the secondary from 0 to 30.33. The secondary volts fell from 101.9 to 98.6. The total power taken up in

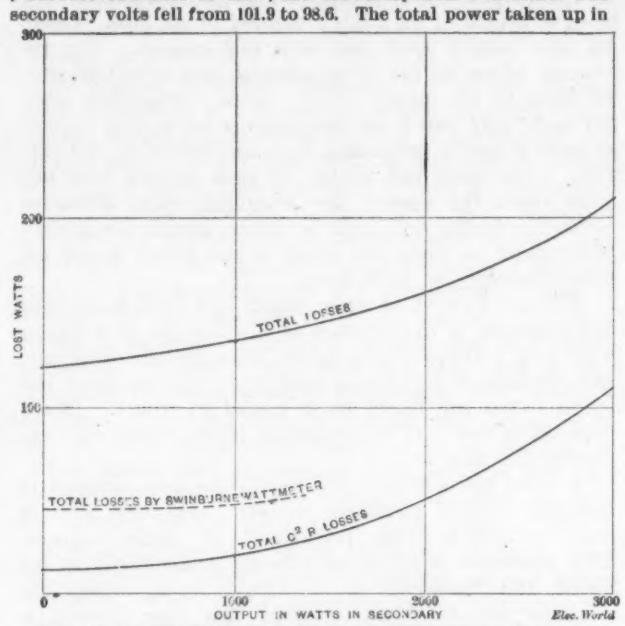


FIG. 12.—3,000-WATT SWINBURNE (HEDGEHOG) TRANSFORMER. LOSSES BY DYNAMOMETER WATTMETER.

the transformer varied between 117 and 217. Table XXIX. shows the following: Secondary volts at no load = 102.00. The primary ampères rose from 0.756 to 1.57; the secondary from 0 to 30.33. The primary copper losses rose from 13.7 to 59, and the secondary from 0 to 46.9. The real primary watts rose from 121 to 3,163 and the apparent primary watts from 1,416 to 3,761. The power factor rose from 0.07 to 6.84.]

Lastly, but by no means least, there are several remarks to make about the "hedgehog" transformer of Mr. Swinburne. As a problem in transformer testing this open-circuit transformer of his is a hard nut to crack. From first to last we have made many hundreds of observations on it. The Tables XXVII., XXVIII. and XXIX. give the results of the two best sets of observations with the dynamometer wattmeter on this transformer. The mean of a number of observations with the dynamometer wattmeter on the power taken up at no load by this transformer gave a value very close to 114 watts. We have already seen that the mean of the three-voltmeter and three-ammeter methods indicated probable values of the power loss close to this number. The dynamometer observations gave values of 114, 108, 108, 114, 114, 121, 121, in seven series of observations at slightly different frequencies. Hence the mean of all means of over 62 observations by three different methods gives the value of 112 watts for the power absorbed at no load in this 3,000-watt "hedgehog" transformer.

The core of this transformer is composed of soft iron wires 18 inches in length, and each 0.9225 of an inch in diameter. The total volume of iron wire is about 856 cubic centimetres, and weighs 5,982 grammes. The induction in the centre of the core is about 10,000 C. G. S. units. It is clear that with such subdivision of the iron, true eddy cur-

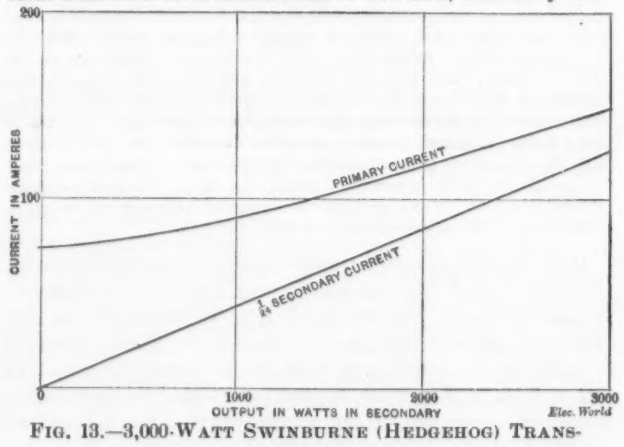


FIG. 13.—3,000-WATT SWINBURNE (HEDGEHOG) TRANSFORMER.

rent loss in the iron must be small, and my estimate of it is that it does not amount to more than 10 or 15 watts at the frequency used. Also the true hysteresis loss cannot probably be much greater than 20 to 30 watts. In general one watt per 30 cubic centimetres of core is about the value of the true total core loss in most usual small-sized transformers. How comes it to pass, then, that all the measurements above described point to a loss of about 112 watts at no load? The answer to this question is, I take it, that there may be considerable eddy current loss in the copper of the secondary circuit. In this transformer the secondary circuit is first wound on the core, and then the primary circuit over it. If we consider for a moment, we shall see that the lines of induction passing up the core return back through the space outside the core, and in so doing they must cut through the copper of the circuits. Hence, at each reversal of induction, unless the copper circuits are exceedingly well stranded, there are eddy currents set up in the copper mass; and this takes place equally well at full and at no secondary load. The only way to prevent this waste is to make the secondary circuit of stranded wire, each strand lightly insulated and very small. It is perfectly clear that this loss must take place to some extent, and that it is a special defect of the open magnetic circuit transformer. We may, from one point of view, regard the function of the iron core of a transformer to be the preservation of the lines of induction in the proper place, and making them thread through the aperture of the secondary circuit without intersecting or cutting through the mass of the copper in that circuit.

I proposed to Mr. Swinburne to obtain convincing proof of the correctness or incorrectness of this view by winding an exactly similar transformer with a dummy secondary circuit of string or rope. If such a transformer with only primary circuit were tested, I believe it would show a far smaller power absorption than the actual transformer does. His firm has not yet been able to try this experiment, but it would be most interesting and satisfactory to have it tried. If we compare the efficiency curve of this transformer with that of a closed magnetic circuit transformer of nearest size, we see that the open magnetic circuit so far gives no advantage in efficiency at the low loads. This "hedgehog" has an efficiency of about 73 per cent. at one-tenth load, and 94 or 95 per cent. at full load. A transformer with a closed magnetic circuit and of not much greater output can be built to do just as well or better than this, as can be seen by an inspection of the efficiency curves of the Kapp or Thomson Houston transformers. If, however, the eddy current loss in the copper can be entirely destroyed, and the large magnetizing current provided by non-wasteful condensers, the open-circuit transformers may perhaps be made more efficient at low loads than closed-circuit transformers of equal output. To attempt to predetermine the efficiency of this type of transformer as now made by calculations carried out on the assumption that the only internal loss is the eddy and hysteresis loss in the iron, leads to considerable overstatement of the efficiency.

If subsequent experiments should confirm this view that at present there is considerable avoidable loss in the copper circuits of the "hedgehog," it is clear we are not yet at the end of our inquiries; and until it has been freed from this defect it does not show inherent superiority over its closed circuit rival. When it has arrived at the ideal con-

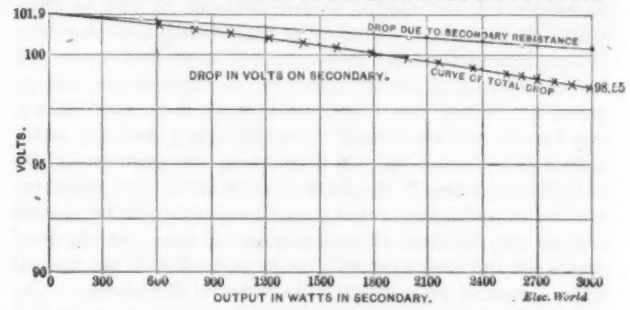


FIG. 14.—3,000 WATT SWINBURNE (HEDGEHOG) TRANSFORMER.

dition, and enjoys the constant presence of a condenser imparting to it its necessary magnetizing current, which in the 3,000-watt "hedgehog" is nearly 50 per cent. of the full load primary current, we shall be in a position to give it a final verdict, and say if the result could not be just as well obtained by adding the necessary small amount of iron to complete the magnetic circuit.

[The relation of the power factor to the secondary output, for several of these transformers, is shown in Fig. 15.]

V.—GENERAL REMARKS ON THE ABOVE EXPERIMENTS.

14. On examining all those diagrams in which are delineated the curves of total loss of power in the transformer and the curve of total copper resistance loss. (C^2R), we see that in every case the upper curve runs sensibly parallel to the lower curve; in some cases most exactly parallel. In the curves for closed magnetic circuit transformers of good design the difference between the total C^2R loss and the total loss of all kinds is the iron core loss in the transformer. Hence we see that all the experiments lead to the conclusion that the iron core losses are constant at all loads. In no case have we found any substantial evidence that the iron core losses are evanescent at full secondary load.

We seem to have very good reason to believe that the total internal loss curve of a transformer can be drawn from observations of the C^2R losses and the total core loss at no load.

15. These measurements have brought out, in addition, another very interesting fact. In the foregoing tables for each transformer will be seen a column of figures headed "Power Factor." We have already defined this term as the ratio of the "true watts" to the "apparent watts" of product of the effective amperes and effective volts. This ratio is given for each measurement of the power. We see at once that for closed magnetic circuit transformers of good type, such as the Mordey, Westinghouse, Ferranti, etc., the power-factor at no secondary load begins at a value of about 0.8 or thereabouts. For such types of transformers, however, a very little loading up of the secondary circuit—not more than one-tenth of a full load—brings the power-factor up to unity. In Fig. 15 are given three curves showing the progress of increase of the power factor as the load on the secondary circuit is progressively increased. The upper curve represents the growth of power factor (P. F.) for the 6,500-watt Westinghouse transformer. Beginning at 0.8, it rises up to unity at about one-tenth of full load. Hence, at and after this very little load the ap-

parent watts are the same as the true watts, and the real power taken up in the transformer is quite accurately given by the product of the primary terminal pressure and the primary current, effective or "square root of mean square" values being understood. For an open magnetic circuit transformer like the "hedgehog" the case is quite different. The P. F. begins at a value of 0.08 or 0.06, and it never rises above 0.8. Hence, at no stage of the load is the real power taken up by the transformer anywhere nearly equal to the "apparent watts." A transformer like the 4,000-watt Kapp appears to occupy an intermediate position, and, although it has a medium power factor to start with, its P. F. rises to unity at about half load. The importance of this fact in alternate current station working is very great. It shows us, if we have a station wholly supplied with transformers of the type of Mordey, Westinghouse, Thomson-Houston, Ferranti, etc., that the apparent watts supplied to the transformers are the real watts at any hour when all the transformers are more than one-tenth loaded. If, however, the station is engineered with "hedgehogs," or with that museum of transformers of all sorts and makes which some central station engineers are fond of gathering together—under the idea, perhaps, that they can "hedge" for economy and make up for the vices of one kind by the virtues of another—then in hardly any state of the load will it be safe to assume the identity of the true and apparent measures of outgoing power. We must, of course, here assume that concentric primary cables are not in use, otherwise an error of another kind may be introduced. If we take the case of a station provided wholly with closed magnetic circuit transformers, and consider it as having an average kind of load diagram, say for the whole year—then if the measure of the "apparent units" sent out from the station is taken, I do not think that in general we shall be far out in our estimate of the true units sent out if we deduct from the apparent units about 12 to 15 per cent, and call the remainder the measure of the true units of energy sent out in the whole time.

16. On looking at the curves in which are delineated the values of the primary and secondary currents for each transformer, we note that in these the value of the primary current and 1-24th part of the secondary current is plotted in terms of the secondary output. These curves are very nearly straight lines. In the case of

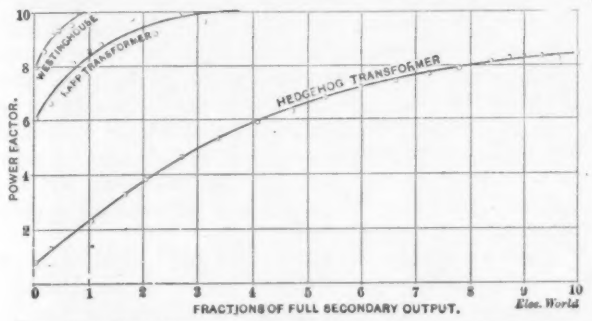


FIG. 15.—RELATION OF POWER FACTOR TO SECONDARY OUTPUT.

the closed magnetic circuit transformers of large power factor the difference between these current values is constant.

Since the winding of these transformers is in the ratio of 24 to 1, it is obvious that the ordinates of the current curves may be taken to represent the primary and secondary ampere turns. If we look at the tables and examine the difference between the values of the primary current and 1-24th part of the secondary current, we shall find this difference is sensibly equal to the primary current at no load, or to the "magnetizing current," so called. This is only another way of stating the fact that the resultant ampere turns are constants at all loads, and equal to the ampere turns at no load. The above is true only for the high power factor transformers. For the open magnetic circuit transformer it is not the case. In this last, the difference between the primary and secondary ampere turns diminishes as the load increases. This is probably because there is a continual change of the relative phase of the primary and secondary currents in the open magnetic circuit transformer as the load is increased; whereas, in the closed circuit, after the first beginning of load, the primary and secondary currents come nearly into opposition with each other as regards phase, and preserve that difference at all greater loads.

There are also, as mentioned, for each transformer a set of curves showing the total secondary drop in volts between no load and any load. Consider the case at full secondary load. The P. D. between the secondary terminals is then less than that between them when the transformer is unloaded; primary terminal P. D. being kept always constant. The difference between these secondary P. Ds. is the "total secondary drop." Part of this drop is due to the volts lost by resistance in the secondary circuit, part by resistance in the primary, and the outstanding portion is the "leakage drop," or lost volts due to magnetic leakage. In all of the "drop" curves, a line is drawn in to indicate the "drop" due to secondary resistance, and in some a dotted line is added also to indicate the drop due to the primary resistance.

If we have a closed magnetic circuit transformer with windings, say, in the ratio of 24 to 1, we have the following rule for obtaining the true magnetic leakage drop, or volts lost by leakage at full load: Add together the product of secondary resistance and secondary current, and 1-24th part of the same product for the primary circuit. Subtract this sum from the total observed drop, and the remainder is the secondary volts lost by magnetic leakage.

Examining in this way all our transformers, we see that in some, such as the Westinghouse, half the observed drop is due to magnetic leakage; while, in some, such as the Kapp transformer, magnetic leakage is very small. This is no doubt due to the way in which the primary and secondary coils are interplaced in the Kapp transformer.

From what has been said above, it is clear that we can, from certain figures of observation on a transformer, predetermine all these curves when that transformer is of the closed magnetic circuit type. For if we are given:

(a) The primary P. D. of terminals;

(b) The primary current at no load, commonly called the "magnetizing current";

(c) The primary and secondary resistances;

(d) The P. D. of secondary terminals, and the secondary current, corresponding to various secondary loads up to full load, we can determine the efficiency curve and everything else. For the product of (a) and (b) gives us the apparent watts at no load, and if we take 0.8 of this we get the core loss at all loads. Then from the ratio of the primary to secondary volts at no load, and the observed secondary currents and magnetizing current, we can calculate the primary currents, and from the currents and resistances get the total C^2R loss at certain secondary loads. Hence, we can draw a total C^2R loss curve and a total loss curve parallel to it, and from this last determine the efficiency at every stage of the load.

[The next section is devoted entirely to a lengthy discussion of the Swinburne wattmeter.—Ed.]

VII.—GENERAL REMARKS ON THE USE OF DYNAMOMETER WATTMETERS TO MEASURE ALTERNATING-CURRENT POWER.

The foregoing experiments impressed upon us the necessity for caution in concluding that any wattmeter of the dynamometer pattern, and however made, would give correct readings of the alternating current power taken up in an inductive circuit. If we consider a simple harmonic current, I, in, and potential difference, V, at the ends of such an inductive circuit, then the mean value of power, W, taken up in the circuit, is $\frac{1}{2}$ I V cos φ, where I and V are the maximum values during the period, and φ is the phase difference of I and V. If φ varies, then the rate at which the measurements of the power W is varied is expressed by $dW/d\varphi = -\frac{1}{2} I V \sin \varphi$, and the ratio of dW/W is therefore equal to $-\tan \varphi \, d\varphi$. Hence a small change in φ produces a greater effect on the value of the error in measuring the resulting power in proportion as φ increases from 0° to 90°.

In the case of an open-circuit transformer there is a very considerable difference of phase between the primary current at no secondary load and the difference of potential between the primary terminals.

Accordingly, if a wattmeter of the dyamometer type is applied to measure the power being taken up in such a transformer at no load, there is a correspondingly great difference between the phases of the currents in the shunt and series coils of the wattmeter. If, then, either by reason of capacity or inductance in the shunt circuit, the phase of the shunt current is displaced by a small amount, the percentage change so introduced into the mean product of the currents—i. e., into the wattmeter reading—is much larger than if the instrument was being used on a transformer of large power factor.

Hence, in the employment of such a wattmeter it is desirable that the movable part of the shunt circuit should have very few turns, and that all metal framework near it be avoided. Generally speaking, it will then be difficult to bestow upon the shunt coil sufficient magnetic moment unless the current in it is comparatively large. This means that considerable power will be dissipated in the wattmeter itself. It is better, however, to employ a wattmeter which uses up a few horsepower, and obtain accurate results with it, than reduce its shunt circuit to a small value and introduce sources of error. It is as necessary to avoid capacity as to annul self-induction in the shunt circuit. As to the external non-inductive resistance in series with the shunt coil, we have, as seen, always preferred to employ a series of incandescent lamps. There is no difficulty in doing this when the means exist for keeping the P. D. between the primary mains constant. Large circuits of incandescent lamps in series are, however, rather unwieldy and expensive. I have been experimenting lately with other methods to obtain the necessary non-inductive resistance for the external shunt circuit of the wattmeter cheaply and in compact form. The conclusion arrived at, however, is that, with proper precautions, a suitable dynamometer wattmeter is a very useful instrument to employ for measuring in a practical workshop-like way the power being taken up in inductive circuits, and that it is much more easy to manage than any of the many other complex methods which look so well on paper and are so difficult to carry out satisfactorily in real life. In any case, a practically non-inductive metal wire resistance is necessary wherewith to standardize the wattmeter in situ and before use; and if the movable coil has very few turns, and no metal near it, and the external shunt circuit is of proper kind, excellent results in measuring alternating current power may be obtained with it.

[The next section is devoted to a discussion of the magnetic behavior of transformers at the moment of connecting them to a circuit.—Ed.]

CONCLUSION.

There are very many derivative matters which, if space permitted, might be discussed as consequences of facts observed in the course of the above-described researches. It is evident, for instance, that the last word has by no means been said on the subject of design of transformers. I have every hope that before long transformer manufacturers may be able to produce transformers of 25 h. p. and upward, having close upon 90 per cent. efficiency at one-tenth of full load. When that is done, it will be interesting to repeat some of those calculations which have already been made as to the relative cost of delivering a certain number of thousand units on an average load diagram, say for distances of 1,000, 2,000, 3,000 yards, etc., by low-pressure feeders and by high-pressure plus transformer feeders Calculations of this kind can be made with some degree of confidence now that it seems clear that the iron losses in transformers are constant at all loads, and that there is a definite relation between this loss and the open-circuit or magnetizing current. We can hardly regard the great controversy of open versus closed magnetic circuits as entirely and definitely settled, but there is no reason to believe that the majority of those who have designed transformers with closed magnetic circuits have been supremely unwise in their faith or in their works.

In the matter of transformer testing, the experience gained in obtaining the facts brought before you has established, in the writer's mind at least, the feeling that a properly constructed dynamometer wattmeter is perhaps the best workshop instrument to use for this purpose, but that its personal character must be strictly examined before trusting too implicitly to the results obtained by it.

The facts and measurements thus obtained have in all cases been sifted and repeated with the greatest possible care, with the desire to arrive at conclusions which should be worthy of confidence, and useful to those engaged in transformer manufacture and design.

A New Electrical Periodical.

The first number of "World's Fair Electrical Engineering," a new monthly periodical devoted to the electrical and allied mechanical interests at the World's Columbian Exposition, is before us. It is a 56-page pamphlet, 6 by 9 inches in size, and handsomely printed and illustrated on heavy paper. As indicated in the title, it is devoted chiefly to World's Fair matters, but variety and added value are given to it by a departmental arrangement in which, under appropriate headings, other subjects are treated, such as the telephone interests, etc. A synoptical index of current electrical literature occupies seven pages, and six are devoted to recent electrical patents.

It is the plan of the editor, Mr. Fred. De Land, to make this periodical a vade mecum for visitors to the Fair, both actual and prospective, and in this we wish him the best of success.

Moonlight Tables for February, 1893.

Herewith we give Mr. H. W. Frund's table of lighting hours for the month of February, under his modified form of moon schedule:

TABLE NO. 1. Standard Moonlight, Philadelphia System.				TABLE NO. 2. Frund's New Moonlight System.			
Date.	Light.	Date	Exting.	Date.	Light.	Date.	Exting.
1	No light.	1	No light.	1	5:20 P. M.	1	12:00 M.
2	5:20 P. M.	2	7:20 P. M.	2	5:20	2	12:00
3	5:20	3	8:20	3	5:20	3	12:00
4	5:20	4	9:20	4	5:20	4	12:00
5	5:30	5	10:20	5	5:20	5	12:00
6	5:30	6	11:20	6	5:20	6	12:00
7	5:30	8	12:20 A. M.	7	5:30	8	12:20 A.M.
8	5:30	9	1:20	8	5:30	9	1:20
9	5:30	10	2:30	9	5:30	10	2:30
10	5:30	11	3:30	10	5:30	11	3:30
11	5:30	12	4:30	11	5:30	12	4:30
12	5:30	13	5:30	12	5:30	13	5:30
13	5:30	14	5:50	13	5:30	14	5:50
14	5:30	15	5:50	14	5:40	15	5:50
15	5:40	16	5:50	15	5:40	16	5:50
16	5:40	17	5:50	16	5:40	17	5:50
17	5:40	18	5:50	17	5:40	18	5:50
18	6:50	19	5:50	18	5:40	19	5:50
19	8:10	20	5:50	19	5:40	20	5:50
20	9:20	21	5:40	20	5:40	21	5:50
21	10:40	22	5:40	21	5:40	22	5:50
22	11:50	23	5:40	22	5:40	23	5:50
23		23		23	5:40	23	12:00 M.
24	1:00 A. M.	24	5:40	24	1:00 A. M.	24	5:40 A.M.
25	2:00	25	5:40	24	5.40 P. M.	24	12:00 M.
26	2:50	26	5:40	25	2:00 A. M.	25	5:40 A.M.
27	3:40	27	5:40	25	5:40 P. M.	25	12:00 M.
28	4:20	28	5:40	26	2:50 A. M.	26	5:40 A.M.
				26	5:50 P. M.	26	12:00 M.
				27	5:50	27	12:00
				28	5:50	28	12:00
Total hours lighting, 193.40.				Total hours lighting, 255.40.			

A Correction.

In The Electrical World for Jan. 14, under the heading "New Books," page 36, we inadvertently credited that useful little handbook "The Lamplighting Schedule on the Moonlight System for 1893" to the Western Electric Company, of Chicago, instead of to the Western Electrician, of the same place. We are glad to make the correction and to place the credit where it belongs.

Electricity at the World's Fair.

THE LIGHTING OF THE GALLERY OF FINE ARTS.

(From Our Special Correspondent.)

The Gallery of Fine Arts is the only one of the Exposition buildings that is built upon a solid foundation, and is fireproof in its construction. It is 500 feet long and 320 feet wide, and has an annex at each end standing back from the main building and connected therewith by galleries. The annexes are each 136 feet by 220 feet and each is surmounted by a dome similar to the large one on the main building. Brick and iron are used almost exclusively in construction, except for floors, etc., and the building is designed to be left as a permanent memorial of the Exposition. It is peculiar in that it contains not a single window, sunlight being admitted through skylights, and incandescent electric lights being the means of illumination employed. About 16,000 lights of 16 c. p. are required. The primary wires are run from the generating plant in Machinery Hall to the Art Building by two routes, those feeding the converters at the east end of the building, following the main subway to the Fisheries Building, and from that point are drawn into pump-log ducts. The wires feeding the west end of the building are drawn into a line of ducts which follow the line of the elevated railroad from Machinery Hall. Lead covered cables are used for this work.

The converter vaults are located under the loggias and in the hollow piers which support the dome, and are built of brick to render them fireproof. The total number of these vaults is thirty-seven, twenty being under the loggias of the main building, three in the piers of the dome of the main building and fourteen under the loggias of the annexes. About eighty converters of 200-light capacity each are required for the 16,000 lights in the building, and they are placed in the vaults on insulating feet, to reduce the danger of grounding.

The secondary mains and feeders rise from the converter vaults to the main cut-out boxes on glass insulators in channels in the brick walls. Those feeding the dome lights are placed within the hollow piers supporting the dome.

The cut-out boxes contain the safety cut-outs, main switches, etc., and vary in size according to the number of circuits run from them, the average size being about four feet square and ten inches deep. They are set into the walls with their doors, which are paneled to correspond with the rest of the wood work, flush with the face. The cut-out boxes are 186 in number, 114 in the main building and 36 in each annex.

The dome is divided in ninety-six panels in four rows. Each panel contains a large rosette, in the centre of which a light is placed. The wiring for these lights is done on insulators between the false dome and the dome proper. As these lights are entirely inaccessible from below, it was necessary to provide means of replacing the lamps from above, and a hole just large enough to allow a lamp to pass through was made in each rosette. The socket is screwed to a wood base, which closes the opening and holds the lamp in position. The tap wires are flexible and long enough to allow the lamp to be withdrawn without disturbing the connections. The dome is encircled by a broad cornice, upon which are placed 200 lights, spaced about one foot apart, and set at such an angle as to effectively light the beautifully sculptured frieze. Four great arches spring from the columns which support the dome, each opening into one of the main courts of the building. The faces of these arches are paneled to corresponds with the ornamentation of the dome, and they have been treated in a similar manner, a 16 c. p. lamp being set in the centre of each panel. Above the arches is a broad band of scroll work, in the figures of which are set 16 c. p. and 32 c. p. lamps, which serve to bring out the beauty of the design.

The main courts, four in number, are to be used for statuary exhibits. They are lighted by means of chandeliers, two in both the east and west courts, and one in each of the smaller north and south courts. Each chandelier carries sixty-nine lights. The feeders for these lights rise in channels in the brick walls to the roof and from there to the ridge in molding fastened to the under side of the iron roof girders with girder loops. The molding carries twelve No. 4 wires for each chandelier. The chandeliers are to be as light as possible, so that the eye of an observer shall not be attracted to them, and are intended as merely supports for the lights. In addition to these chandeliers, each court is lighted by lamps set in ornamental rosettes on the faces of the galleries about two feet apart, and by still another row set in rosettes in the frieze just below the roof.

The picture galleries are seventy-eight in number, thirty-six in the main building, eighteen in each annex and six in the connecting galleries. They are built with cove ceilings, a large skylight occupying the central portion. Between this ceiling and the roof is an open space with head room for wiring, and the feeders are run on insulators in this space.

All the lights are mounted in the Frink reflectors, which are used to screen light from the observer, and to throw the light upon the pictures. There is a total of about 217,000 square feet of picture space, and it will require not far from 10,000 linear feet of reflectors. These are suspended from the ceiling by hollow standards, through which the feeders pass to the mains in the screens. The lamps are wired on double circuits, lights on one circuit alternating with those on the other, so that the blowing of a fuse, or other interruption of the service from local causes, would not leave any part of the exhibit in darkness. All the space in the annexes is devoted to picture galleries, with the exception of the rotundas of the domes, which will be used for exhibits of statuary. These small domes are not treated like the main dome, but are illuminated by a forty-light chandelier in each.

The space devoted to the exhibits of pen and ink and crayon pictures is on the main floor of the courts, under the galleries, and also in the galleries. The space is divided into open stalls by partitions twelve feet high and about the same in depth, the stalls being about thirty feet long. Those on the main floor are lighted by five-light clusters, two in each stall, on flexible pendants hung from beneath the gallery. The stalls in the gallery are also lighted by two five-light clusters in each. Owing to the great height of the roof above the gallery, it was not thought desirable to drop a pendant cord therefrom, so a short standard has been placed upon each partition at the centre. A flexible cord is stretched from one to the other, and the clusters are connected to this cord, which supplies the current. A very fine piano wire dropped from the ceiling supports the weight of the cluster, but is so fine as to be almost invisible.

Exterior Lights.—In the ceiling over the entrances of both the main building and annexes are double rows of panels with large rosettes in the centres. In each of these rosettes is a cluster of three 16 c. p. lights. As these are so high as to be out of reach from below, it was necessary to devise a method of reaching them to renew burnt-out lamps. The wiring for these lights is done in the space above the ceiling, where there is ample headroom. It was not advisable to cut a hole large enough to withdraw a three-light cluster, as was done with single lamps in the dome, so a small hole was cut for a flexible cord to pass freely through, and the connections are made through "bug" cut-outs. When it is desired to replace a lamp, the connection is broken at the cut-outs and the cluster lowered to the floor beneath by a cord.

A lofty colonnade extends around the main building and along the galleries connecting with the annexes. In the panels of the ceiling of this colonnade are placed lights, one to each panel. These are arranged to be withdrawn and renewed from above.

In this building the lights are not used in a decorative way, except in domes, entrances and colonnades. They are regarded as sources of light simply, the question of utility being alone considered.

The Administration Building, which we present to our readers this week in a new aspect, will be seen to be no less imposing at night than in the daytime. Located at the head of the great basin, at the intersection of the main, central and transverse axes of the grounds, around which are arranged in more or less symmetry the other main buildings of the Exposition, it was designed to be the loftiest and most purely monumental composition in the park, and to serve not only for the accommodation of the various bureaus of administration, but more conspicuously as the great porch of the Exposition.

Situated midway between the great Machinery Hall, where the electrical current is generated, and the Electricity Building, where its many applications are displayed, it is but appropriate that it should form the connecting link between the two. The most imposing structure of all by day, it should not be obscured by night, and for this reason its lines have been preserved during the latter season by myriads of lights, as shown in the accompanying engraving.

Covering an area 260 feet square, its lofty dome reaches an altitude of 275 feet, and this in each of its ribs is outlined in incandescent lamps. The whole is surmounted with powerful search lights, which are strikingly portrayed in the picture.

Each of the twenty-four panels into which the octagonal dome is divided is illuminated in its centre by a circle of lamps, and at its base by garlands or festoons of the same nature. Descending to the second story of the structure, which is Ionic in style of architecture, with an open colonnade or loggia on each of the faces of the octagon, a beautiful effect has been produced by the reflected light of concealed arc lamps. This plan of concealing the lamp itself and distributing only its softened reflected rays is one that is coming much into favor, is capable of beautiful adaptations and is here very happily employed.

Surrounding the building at a distance of 50 feet from its wall are arranged, in the form of a square, 36 arc lights of 2,000 c. p. each, and in addition to these at each corner is located a group of five similar lamps, supported on tasteful and ornamental poles, which form a square whose sides inclose the one before described.

In regard to the interior illumination, Mr. Henry Van Brunt, in the "Century Magazine," speaks thus: "The method of lighting the interior of this vast domelike chamber in a proper and adequate manner was a problem so important that Mr. Hunt, the architect, considered it one of the primary formative influences controlling the evolution of his architectural scheme. One of the noblest effects of interior illumination known in historical art is in the Roman Pantheon, the area of which (140 feet in diameter) is lighted only by the circular hypethral opening 25 feet wide at the apex of the dome, 140 feet from the pavement. Inspired by the majestic example, Mr. Hunt proposed in this respect to depend mainly upon such light as could be obtained from the open eye of his lower dome, 50 feet wide and 190 feet from the pavement, which should in turn borrow its light from the illumination of the space between his outer and inner domes through a glazed hypethral opening 38 feet wide, forming the summit of the building, and taking the place of the lantern or belvidere which usually forms the finial of the greater domes of the Renaissance."

While the above description applies specifically to the daylight illumination of the interior of the Administration Building, it also outlines the general plan adopted for the electrical illumination at night. By concealing the lights between the two domes, their reflected rays give a softened, diffused light in keeping with the sensations aroused by the grandeur of the surroundings and the importance of the event they are intended to commemorate.

In last week's issue of The Electrical World there was given a view of the magnificent fountains, unsurpassed to this time by any attempts hitherto made. To this the Administration Building and the vault of heaven formed a fitting background. This week is given a nearer view of the former, showing more in detail the features which will make it memorable.

World's Fair Notes.

Mr. Frederick Sargent, the mechanical and electrical engineer, returned last week from a short trip in the East, which he undertook on account of several matters connected with the Exposition work.

Among other business he negotiated with the Climax Boiler Company, of New York, for three more boilers to be added to the main boiler plant, one of which is 1,000 commercial horse power capacity and the others 500 h. p. each. These boilers are of quite a different type from any others in the plant, being of the vertical type, while all others will be horizontal. This will probably complete the number of boilers required for the power plant, though a few foreign or other boilers may be installed as exhibits. The total plant now contains a total "continuous working evaporation" capacity of 510,000 lbs. of water per hour, an equivalent of 17,000 commercial boiler horse power. The boilers are guaranteed to work up under necessity to 20 per cent. above their rating, and by far the greater number of engines in the plant are compound or triple expansion, developing a horse power on from 11 to 22 pounds of water. The boilers are considered ample for the power, from 20,000 to 27,000 h. p., which will at times be required of them.

The Climax boilers will be installed as soon as the weather moderates sufficiently to admit of putting in foundations. The very cold weather which has prevailed for the past two weeks has interfered considerably with brick and concrete work, though a considerable amount has been done notwithstanding, and such work as pipe fitting has progressed as usual.

Two of the big Westinghouse dynamos were given a trial start at the works of the Westinghouse company, in Pittsburgh, last week, and will be immediately shipped to Jackson Park. Four of the pulleys for the six-belt driven machines have already arrived, and, as they stand on the floor of Machinery Hall—9 feet in diameter and 6 feet face—they create considerable remark, and people wonder what is going to drive a pulley like those.

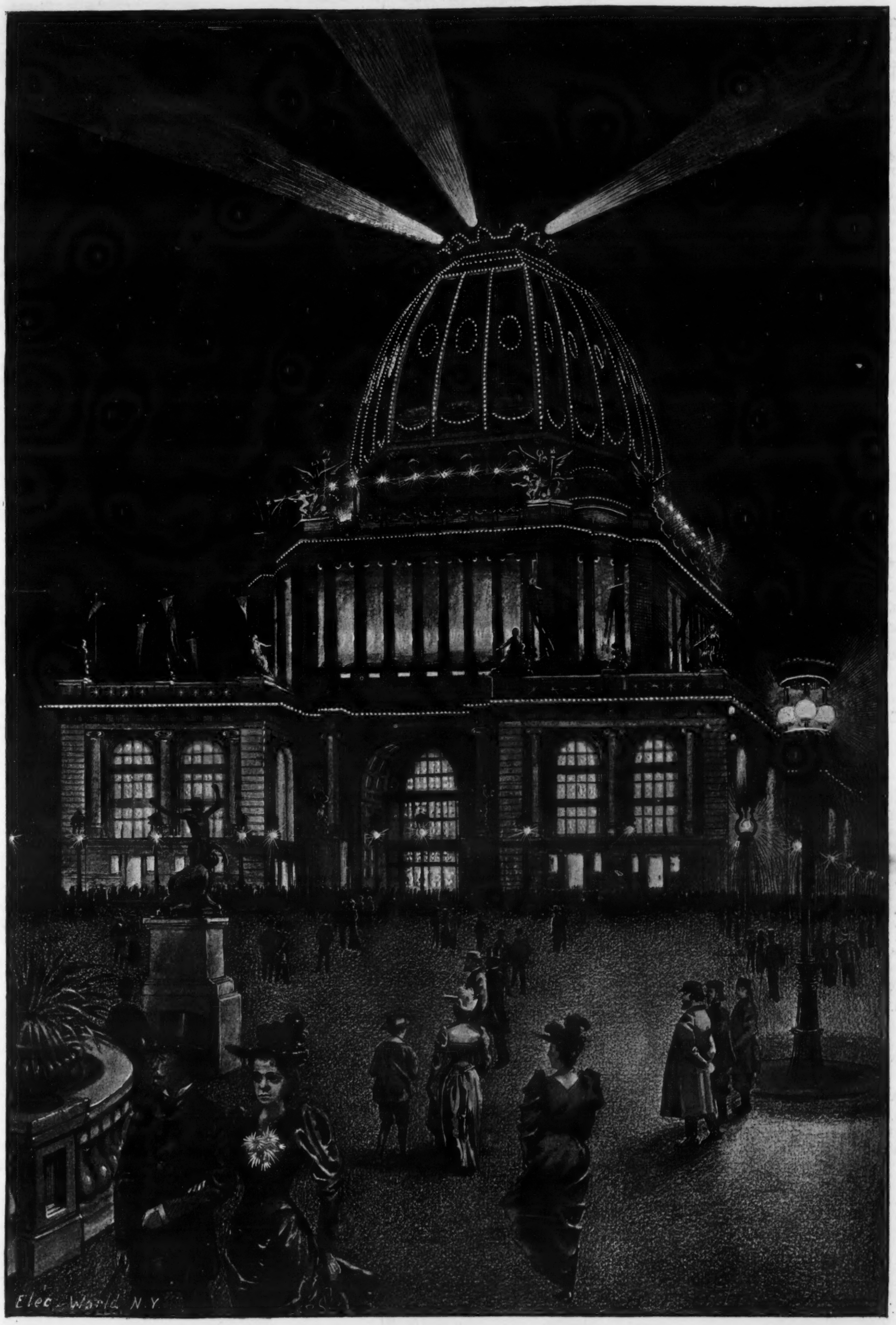
These dynamos are by far the largest of the kind ever manufactured, and the Westinghouse company has introduced several new features into the detail of their construction.

The World's Fair Commissioners have provided for a very fine exhibition of belting in motion. Two belts seventy-two inches wide will be run tandem, and are to produce 2,000 h. p. In the same group another six-foot belt will be run, estimated at a capacity of 1,000 h. p. There will be three more six-foot belts, every one estimated at 1,000 h. p., in another group; these belts are furnished by the following firms: Fayerweather & Ladew, Jewell Belting Company, Page Belting Company, and Chas. A. Schieren & Co. The last named firm will also furnish a six-foot three-ply belt perforated. This will be the largest perforated belt ever made and put in motion, and there will be an opportunity to thoroughly test the advantages of perforations, as the conditions, lengths, etc., will be like the other belts not perforated.

The American Leather Link Belt Company will make a novel exhibit by having two of their belts run tandem, with a flat belt over their link belt; the flat belt will be an electric belt furnished by Chas. A. Schieren & Co.

While the subject of leather belting is one of the greatest importance in all transmissions of powers, it is one that is almost always slighted in descriptions of power installations and is therefore lost sight of by those not more immediately interested.

Considerable space has been set apart for the display of these goods in the Electricity Building, however, and, as indicated above, the different makes will be seen in motion in the Machinery Hall, forming, without doubt, the most comprehensive display of the kind ever attempted.



THE ADMINISTRATION BUILDING BY NIGHT.

Some Mechanical and Electrical Analogies.

BY F. BEDELL AND A. C. CREHORE.

No phenomena are so readily comprehended as those which may be compared directly with facts that are familiar, and no reasoning is so quickly grasped as reasoning "by analogy." The analogies between certain mechanical and electrical relations are so striking that when either relations are understood the others follow, and from the laws of mechanics we can readily write those of electricity. The process is a reversible one and the electrician can with equal ease step over into the realms of dynamics. To enable one to reason accurately in this manner and to reach definite results with absolute certainty, it is necessary to give with exactness the fundamental relations of mechanics and electricity. The following tables are, therefore, given showing the analogies between linear motion, motion of rotation and the electric current. Starting a current of electricity in a circuit is analagous to imparting motion to a body and requires an impressed force. This force must overcome the resistance (electrical resistance corresponding to that of friction) and the inertia of the mass or current.

In the case of the electric current this inertia is called "self-induction." A revolving flywheel may well represent the flow of electricity, its velocity corresponding to the current, its moment of inertia to the co-efficient of self-induction and the friction to ohmic resistance.

TABLE I.—LINEAR MOTION.

Notation.

1. Time $= t$.
2. Distance $= s$.
3. Linear velocity $= v = \frac{ds}{dt}$. $ds = v\,dt$.
4. Linear acceleration $= a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$.
5. Mass $= M$.
6. Momentum $= M\,v$.

Frictional Resistance.

7. Frictional resistance $= R$.
8. Force to overcome resistance $= F_R = R\,v$.
9. Energy expended in overcoming resistance in the time $dt = dw_R = F_R ds = R\,v^2\,dt$.

Inertia.

10. Force to overcome inertia $= F' = M\,a = M\frac{dv}{dt}$.
11. Kinetic energy acquired in the time $dt = dw' = F'\,ds = M\,v\frac{dv}{dt}\,dt$.
12. Kinetic energy $= w' = \int_0^v M\,v\frac{dv}{dt}\,dt = \frac{1}{2}\,M\,v^2$.

Inertia plus Resistance.

13. Total force applied $= F = F_R + F'\ R\,v + M\frac{dv}{dt}$.
14. Total energy supplied in the time $dt = dw = dw_R + dw'$, or $F\,ds = F_R\,ds + F'ds$; or, $F\,v\,dt = R\,v^2 dt + M\,v\frac{dv}{dt}\,dt$.

TABLE II.—ROTARY MOTION.

Notation.

1. Time $= t$.
2. Angle $= \varphi$.
3. Angular velocity $= \omega = \frac{d\varphi}{dt}$. $d\varphi = \omega\,dt$.
4. Angular acceleration $= \alpha = \frac{d\omega}{dt} = \frac{d^2\varphi}{dt^2}$.
5. Moment of inertia $= I$.
6. Angular momentum $= I\,\omega$.

Frictional Resistance.

7. Frictional resistance $= R$.
8. Torque to overcome resistance $= T_R = R\,\omega$.
9. Energy expended in overcoming resistance in the time $dt = dw_R = T_R\,d\varphi = R\,\omega^2\,dt$.

Inertia.

10. Torque to overcome inertia $= T' = I\,\alpha = I\frac{d\omega}{dt}$.
11. Kinetic energy acquired in the time $dt = d\,w' = T'\,d\varphi = I\omega\frac{d\omega}{dt}\,dt$.
12. Kinetic energy $= w' = \int_0^\omega I\,\omega\frac{d\omega}{dt}\,dt = \frac{1}{2}\,I\,\omega^2$.

Inertia plus Resistance.

13. Total torque applied $= T = T_R + T' = R\,\omega + I\frac{d\omega}{dt}$.
14. Total energy supplied in the time $dt = dw = dw_R + dw'$; or, $T\,d\varphi = T_R\,d\varphi + T'\,d\varphi$; or, $T\ \omega\ dt = R\omega^2\,dt + I\,\omega\frac{d\omega}{dt}\,dt$.

TABLE III.—ELECTRIC CURRENT.

Notation.

1. Time $= t$.
2. Quantity $= q$.
3. Current $= i = \frac{dq}{dt}$. $dq = i\,dt$.
4. Current acceleration $= \beta = \frac{di}{dt}$.
5. Co-efficient of self-induction $= L$.
6. Electromagnetic momentum $= L\,i$.

Ohmic resistance.

7. Ohmic resistance $= R$.
8. Electromotive force to overcome resistance $= e_R = R\,i$.
9. Energy expended in overcoming resistance in the time $dt = d\,w_R = e_R\ dq = R\,i^2\,dt$.

Self-induction.

10. Electromotive force to overcome self-induction $= e' = L\,\beta = L\frac{di}{dt}$.
11. Energy acquired by the magnetic field in the time $dt = dw' = e'dq = L\,i\frac{di}{dt}\,dt$.
12. Energy of magnetic field $= W' = \int_0^i L\,i\frac{di}{dt}\,dt = \frac{1}{2}\,L\,i^2$.

Resistance plus self-induction.

13. Total electromotive force applied $= e = e_R + e' = R\,i + L\frac{di}{dt}$.
14. Total energy supplied in the time $dt = dw = dw_R + dw'$; or, $e\,dq = e_R\,dq + e'\,dq$; or, $e\,i\,dt = R\,i^2\,dt + Li\frac{di}{dt}\,dt$.

A study of the tables will make these analogies more clear. It is to be noted that the flywheel or moving mass

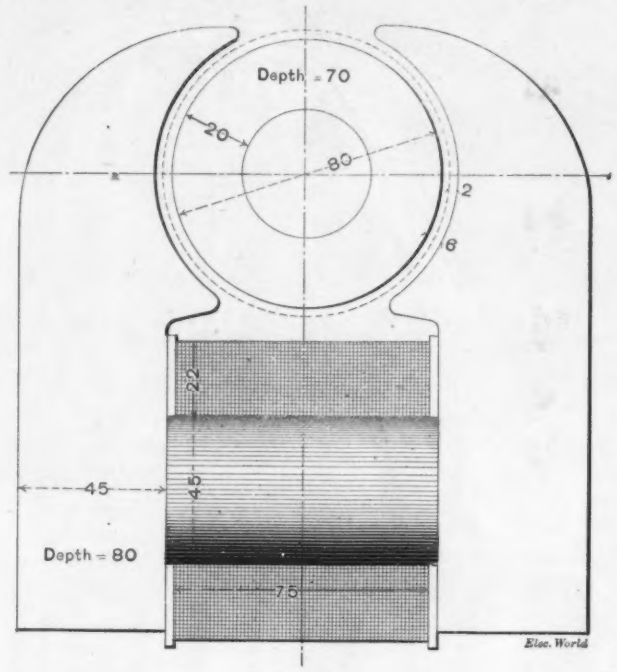


FIG. 2.

in slowing down gives back its kinetic energy and the wheel is carried on, after the impressed force is removed, until this is entirely consumed in overcoming friction. Similarly, when the current diminishes upon the removal of the impressed electromotive force, the energy stored in the magnetic field is restored to the circuit and the current keeps flowing until the energy is entirely used up in overcoming the ohmic resistance.

These analogies cannot be considered as rigorous proof. The truth of the relations here given for the electric current has been fully established and may be found in the introductory chapter to our work on "Alternating Currents." Other striking analogies will suggest themselves, but space will not permit calling attention to any but the most fundamental ones given above.

Calculation of a Small Electric Motor of 10 Kilogrammetres.—II.*

BY E. MEYLAN.

We will now proceed to see how, with a Siemens winding and a magnetic frame with a single field coil, the best conditions can be realized as to speed and the number of turns necessary, both on its armature and field coil, with practically the same weight of wire.

Calculation of a Motor with a Drum Armature.—A calculation of the same kind gives the dimensions shown in Fig. 2. For this second example we will be content to give the final results obtained. We will take for an angular velocity: $n = 2{,}000$ revs. per minute; $N = 900$ turns of wire 0.5 mm. in diameter, $D = 8$ cm., $d = 4$ cm., $b = 7$ cm., $a = 2$ cm. The surface of iron then will be $S_1 = 0.8 \times 2 \times 2 \times 7 = 22$ cm.²

The counter electromotive force $e = 80$ volts; $i = 1.7$ amperes; $y = 60\%$.

$$F = \frac{30}{n}\,\frac{e\,10^8}{N} = \frac{30}{2{,}000}\,\frac{80 \times 10^8}{900} = 134{,}000;$$

$$\beta = \frac{134{,}000}{22} = 6{,}100.$$

Assuming a magnet core of soft iron and two pieces of cast iron forming the pole pieces, we will take, for the armature:

$$\beta_a = 9{,}000;\ S_1 = 18\text{ cm.}^2;\ d_a = 4.5\text{ cm.},$$

and for the pole pieces:

$$\beta_p = 4{,}500;\ S = 36\text{ cm.}^2 = 8 \times 4.5.$$

The corresponding magnetic forces are: for $\beta = 6{,}100$, $H = 4$; for $\beta_a = 9{,}000$, $H = 6$; for $\beta_p = 4{,}500$, $H = 15$.

The length of air space is made up as follows;

Insulation	1 mm
Four layers of 0.6 mm. wire	2.5 "
Air gap	2.5 "
	6.0 mm.

On the other hand the surface of the field determined as above is:

$$S_f = 8 \times 10 = 80\text{ cm.}^2$$

or

$$H = \frac{134{,}000}{80} = 1{,}800.$$

We will then have:

$$n^1\,i_{a-t} = \frac{10}{4\pi}\,\Sigma\,H\,l = \frac{1}{1.25}\Big[\underbrace{\text{Air space}}_{1{,}800 \times 1.2} + \underbrace{\text{Arm. core}}_{4 \times 8} + \underbrace{\text{Field core}}_{6 \times 7.5} + \underbrace{\text{Pole pieces}}_{15 \times 20}\Big] = 2{,}100.*$$

It is necessary to count about 200 more ampère turns for the armature reaction, or about 10 per cent.

$$n^1 = \frac{2{,}300}{1.7} = 1{,}350\text{ turns of 1 mm. wire.}$$

With a length of magnet equal to 7.5 cm. there will be necessary 20 layers, or a depth of 22 mm. of wire. The total resistance will then be 5.6 ohms. The losses in volts $= 5.6 \times 1.7 = 9.5$; loss in watts $= 9.5 \times 1.7 = 16$.

For the armature we will take a wire 0.8 mm. in diameter; it will require four layers, as indicated above (each layer occupying two spaces on the circumference). It is necessary to count on a length of 36 cm. per turn on account of its heaping up at the two ends; the total resistance of the wire will be 26 ohms, making the resistance of the armature equal to 6.5 ohms. The loss in volts $= 6.5 \times 1.7 = 11$; loss in watts $= 11 \times 1.7 = 19$ watts. The total loss in volts is then $11 + 9.5 = 20.5$; we have assumed 20 volts, so the speed can be lower one-half of 1 per cent.

The calculation of the hysteresis gives a loss of four watts; the useful electric power will then be equal to:

$100 \times 1.7 - (16 + 19 + 4) = 131$ watts $= 13.3$ kgm.-sec.

There remains, then, a surplus of 3.3 kgm., or 25 per cent. of the useful power, to lose in mechanical friction. This is a little less than in the first case, as it should be, since the speed is so much lower, and therefore the weight may be greater.

The two types that we have undertaken to calculate will then be almost exactly equivalent from the standpoint of the results obtained. The second type will have the advantage as to speed. As to the weight of the copper we have found:

First type.		Second type.	
Armature	0.6 kg.	Armature	0.6 kg.
Fields	1.6 "	Field	2.0 "
Total	2.2 kg.	Total	2.6 kg.

The ratio is far from being equal to that of the speeds; that is, to say, if we were able to give the second motor a velocity of 7,000 revolutions, it would be possible to save copper. This economy will be greater if we replace the cast iron pieces by ones of soft iron or cast steel. It seems that under these conditions the drum armature would be preferable. We would arrive at the same conclusion if we considered the price of the labor for winding the coils.

We hope that these two examples, calculated at length, will be useful to those of our readers whom these questions interest. It will be easy for them by following the same method to calculate dynamos and motors under the varied conditions of practice, provided that they make a judicious selection of the different factors and coefficients introduced into the formulas.

The Canadian Electrical Association.

The next convention of the Canadian Electrical Association will be held at the School of Practical Science, Toronto, on Wednesday and Thursday, Jan. 25 and 26. In connection with this, the following programme has been announced:

WEDNESDAY, Jan. 25.—2 P. M.—President's Address; Secretary-Treasurer's Report; Reports of Committees; paper by Mr. George Black, of Hamilton, on "Electrical Measurements;" paper by Mr. W. A. Tower, Toronto, on "Underground Construction." An invitation is extended to the members of the Association to visit and inspect the Toronto Electric Light Company's new station. 8 P. M.—Dinner at McConkey's.

THURSDAY, Jan. 26.—10 A. M.—Discussion on proposed Amendments to the Constitution; paper by Mr. J. M. Campbell, of Kingston, on "Free Wiring;" paper by Mr. R. G. Black, of Hamilton, on "The Incandescent Lamp;" paper by Prof. Rosebrugh, School of Practical Science, Toronto, on "Speed Control;" paper by Mr. Breithaupt, of Berlin, Ont., on "Probabilities as to the Success of Distribution of Power at Considerable Distances by High Tension Currents of Electricity." The members are invited to visit and inspect the Bell Telephone Company's new Exchange.

Mr. George Black, of Hamilton, under the caption "Electrical Measurements," will discuss this important subject under the following headings:

1. Early days of the telegraph and lack of testing methods.
2. Laying of the Atlantic cable led to more scientific methods in the United States and Canada.
3. Advent of electric lighting, using heavy currents, indicated necessity for new terms and appliances.
4. Ohm's law, explained and illustrated, in measuring current, electromotive force and resistance.
5. Description of testing instruments and examples from actual practice in testing telegraph lines.
6. Desirability of regular and systematic testing of all telegraph telephone, electric light, power and other circuits.

The Use of Gas Engines for Electric Lighting.

To the Editor of The Electrical World:

I would like to get the experience of some of the readers of THE ELECTRICAL WORLD in electric lighting, with a gas engine for power—comparative cost, steadiness of speed, etc.

JOHN M. FADYEN.

* From *L'Electricien*. For the first section of this article see THE ELECTRICAL WORLD of Jan. 21, 1893, page 48.

* The length of the lines of force is equal to about 8 cm. in the iron of the armature core, 7.5 cm. in the core of the electromagnet and 20 cm. in the two cast-iron pole pieces.

Important Meeting of the Advisory Council of the Chicago Electrical Congress.

A meeting of the Advisory Council of the Chicago World's Congress of Electricians was held at the rooms of the American Institute of Electrical Engineers, New York, on Jan. 17.

The following gentlemen were present: Dr. Elisha Gray, Chairman; Prof. Wm. A. Anthony, Prof. Chas. R. Cross, Dr. Louis Duncan, Dr. Wm. Geyer, Mr. Carl Hering, Mr. Geo. A. Hamilton, Prof. F. B. Crocker, Mr. A. E. Kennelly, Mr. T. D. Lockwood, Mr. T. C. Martin, Mr. Geo. M. Phelps, Dr. M. I. Pupin, Mr. R. W. Pope, Prof. H. A. Rowland, Dr. Herbert Laws Webb.

Mr. H. L. Webb was elected secretary of the meeting, in the absence of Prof. Carhart, permanent secretary of the council. The preliminary reports of the English and American committees, already made public, were received.

It was resolved that the Electrical Congress of 1893 shall consist of two chambers, of which the Legislative Chamber shall decide on units, names of units, and standards, and shall consist solely of delegates named by their respective governments.

A committee was appointed to determine the total number of official delegates and their apportionment to the various countries to be represented.

The following apportionment of delegates was made by the committee, whose report was adopted by the meeting: Great Britain, 5; France, 5; Germany, 5; Austro-Hungary, 5; United States, 5; Belgium, 3; Italy, 3; Switzerland, 3; Holland, 2; Denmark, 2; Norway and Sweden, 2; Russia, 2; Spain, 2; Portugal, 1; British North America, 1; Australian Colonies, 1; India, 1; Japan, 1; China, 1; Mexico, 1; Brazil, 1; Chili, 1; Peru, 1; Argentine Republic, 1; making a total of 55 official delegates.

It was resolved that a Committee on Invitations be appointed by the chairman, this committee to consist of five members who shall select and recommend to the chairman the names of electricians, electrical engineers and others who shall be members of the Electrical Congress, said committee to co-operate with the foreign committees.

It was further resolved that in addition to invitations to deliberating and voting members of the Congress, a general intimation shall be extended through the journals or otherwise that the meetings will be open to the public for attending the proceedings, but not for taking part therein.

It was resolved that a Committee on Programme and Papers be appointed by the chairman. This committee shall consist of eight members, whose duty it shall be to invite, receive and consider papers and other documents relating to the work to be done by the Congress. And it was further resolved that it shall be the duty of this committee to formulate a programme for the Congress.

It was resolved that the reports of the English and American sub-committees, which were received at the meeting, should be referred to the Committee on Programme and Papers, and that the committee confer with the English committee as fully as possible and with such other foreign committees as may be formed.

It was resolved that the Electrical Congress of 1893 shall last one week, beginning on Aug. 21.

It was resolved that a committee of three be appointed by the chairman as a Finance Committee.

It was resolved that an Executive Committee of five shall be appointed by the chairman, said committee to have full power to act for the Advisory Council.

It was resolved that the question of charging a fee for membership of the Congress, and fixing the amount of such fee, be referred to the Executive Committee.

The New Separable Lamp.

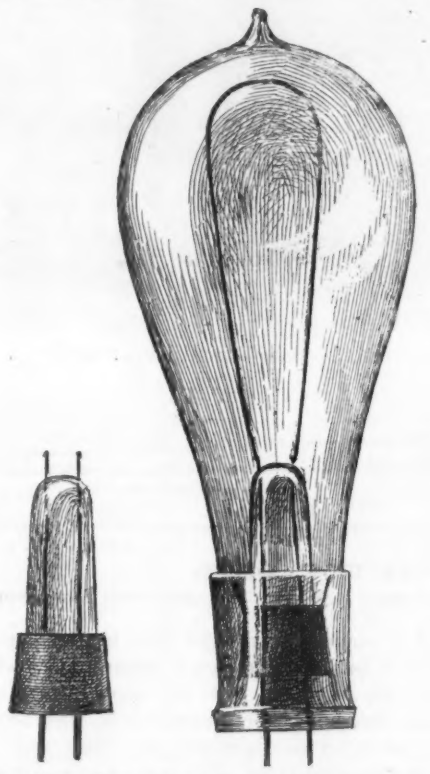
The mystery which has so long surrounded the new lamp of the Westinghouse Electric and Manufacturing Company is no more. Early last week invitations were issued by that company to inspect at their shops in Pittsburgh the large lighting dynamos that were built for the World's Columbian Exposition, and, also, the new lamp, about which so much has been said and expected. It seems that the delay in putting the latter upon the market has been due, not to any indecision as to the character the lamp should assume, or the difficulties encountered in its operation after its manufacture, but to the perfection of the machinery required to produce it in large quantities at a nominal cost. The Westinghouse company seems to have regarded as one of the first essentials to success the production of a lamp complete in itself at the smallest possible cost.

The accompanying cut represents quite accurately the preferred form, which is not unlike what we were led to expect from the meagre hints that have been from time to time thrown out.

As will be seen, the pear-shaped globe is retained, but its lower end is given a shoulder, and is thickened out considerably after the manner of finishing the neck and mouth of a bottle. The interior of this opening is conical in shape and carefully ground for the stopper. The latter is also of glass, and is illustrated in full size. The stopper proper is also carefully ground to fit the bottle neck, but is continued within as part of the seal. The whole is a single piece which is cast around the leading-in wires in the process of manufacture, thus constituting a seal throughout the whole length of its major axis. An innovation in this portion of the lamp is the substitution of iron for platinum in its construction. This has been rendered necessary for two reason. In the first place, the method of casting the seal around the wires rendered the employment of a metal not fusible at the temperature of molten glass imperative. Platinum is too expensive, and iron was found to answer. In the second place, the plan of the lamp, which is complete without the usual base, required the terminals to be strong enough to withstand without bending the lateral strains to which they are subjected when making contact with the circuit terminals in the socket. For this purpose iron was well adapted, and to increase the rigidity the terminals were made large, as shown in the cut.

The filament, having been attached to the leading-in wires, the stopper having been covered on its bearing surface with a varnish or cement, is tightly introduced into the bottle-necked receptacle, and exhaustion of the bulb through the opposite end is proceeded with. In this latter operation, the specifications of the Sawyer-Man patent are followed, nitrogen gas being from time to time introduced and withdrawn again for the purpose of entirely washing out the remanent atmosphere with its accompanying oxygen.

The extent of the vacuum produced is not stated, but it is believed that it is as perfect as can be made, and that the attenuated atmosphere of nitrogen, which has been announced as a feature of the lamp, is merely that small portion which is left behind after all that can be exhausted has been removed.



THE NEW SEPARABLE LAMP AND STOPPER.

The atmospheric pressure from without tends to more tightly seal the stopper, and the cementing material, which is elastic, is warranted not to crack. By warming this it softens, allowing of the removal of the stopper on admission of air to the bulb, but the atmospheric pressure prevents its accidental removal or loosening in use.

As seen in the cut, the lamp is complete without base. By simple pressure its shoulders are held in springs in the socket and a twist of 90 degrees brings its terminals in contact with the circuit terminals and the lamp is brought to incandescence.

Simplicity is one of the striking characteristics of the lamp, and the manufacturers seem to have accomplished their purpose of cheapening its manufacture without seriously cheapening its appearance.

The question which most naturally arises is, will not the greater coefficient of expansion of the iron leading-in wires cause a cracking, and, therefore, a leakage in the seal. The manufacturers claim that experience proves that it does not.

Meeting of the St. Louis Electric Club.

A large and enthusiastic meeting of the St. Louis Electric Club was held at St. Louis on Saturday evening. Jan. 21. President Anderson, of the St. Louis Chamber of Commerce, President Jaiennie, of the St. Louis Exposition, and many other prominent citizens were present. Joint committees with the leading commercial bodies were appointed. Secretary Porter and Superintendent of Transportation Baker, of the National Electric Light Association, who were in St. Louis in consultation with President Ayer arranging the preliminaries of the convention, were also present at the meeting. The Club will provide entertainment for the members of the Association at the meeting next month. An interesting feature of the meeting was the announcement of President Ayer that Nikola Tesla would deliver a lecture before the convention, which would be open to the public and illustrated by numerous experiments.

The Pruyn Elevated E ectrical Railway.

Various systems of rapid transit, in which only one rail was to be used, have been proposed from time to time, but no practical system seems to have been evolved, although experimental roads have been constructed and operated for a short period. Mr. Henry S. Pruyn, of Hoosick Falls, N. Y., has devised a system which he claims overcomes all the difficulties which have hitherto been encountered, and which renders entirely practical this very interesting form of construction. Mr. Pruyn is making efforts to have his road constructed on the World's Fair Grounds and exhibited in actual operation during the Exposition.

The accompanying description will give a clear idea of the elevated structure, the form of the cars and the various details of the system. The track consists of one rail carried on the top of single girders placed at proper intervals. The cars are operated by electricity, which is supplied by the double trolley system. The conductors are carried under the lower flange of the rail, where they are entirely protected from mechanical injury as well as from the effects of the weather, and from dust and dirt. There is also space under this flange for the suspension of telephone, telegraph or electric light wires, which would not be subject to the annoying effects of induction that would be noticed if only one wire and the ground return were used.

The car wheels come up into the centre of the car, and the seats for the passengers are arranged lengthwise of the car, back to back, with sufficient space between them and the sides of the car to allow of the passengers and the motormen easily moving from one end to the other. The passengers enter the car by doors at the sides, but doors at the end are also provided for the convenience of employees. The carrying wheels bear the car by the means of heavy pins with spring bearings, upon which the weight of the car rests. The car is of much lighter construction than would be possible in any other form, while at the same time it possesses the requisite strength and rigidity. Thus, not only is the centre of gravity very low, but it is even below the surface of the rail, which destroys the tendency of the car to tip from one side to the other, or to leave the track. This form of construction renders a much higher speed possible than would be safe with any ordinary car. The current is taken from the conductors by means of two wheels, which also serve as guide wheels, and form an additional safeguard against the car leaving the track. Good contact is always secured without undue friction.

One of the advantages claimed for the Pruyn system is that flange friction is done away with to a large extent, and that on rounding curves there is none of the sliding friction which always takes place in a double rail road. The motion at high rates of speed is also said to be very much easier than in the ordinary steam railroad, or even in electric roads, as there is none of the swaying or vertical motion.

The structure does not interfere in any way with surface roads, or prevent the land which it crosses from being used for agricultural purposes any more than a row of trees would. No grading, ballasting, draining, fencing, and no culverts, telegraph posts, or small bridges are necessary. The advantage which it possesses over the ordinary elevated structure is that it does not disfigure the street nearly as much, and does not in the least darken it. The objectionable noise is also avoided to a large extent. On account of its great simplicity this structure can be built at a very small cost, and the expense of keeping it in running order is exceedingly low.

This road, of course, possesses all the advantages which other electric systems claim, can be easily operated on the block system, so that collisions are impossible and accidents from switches and drawbridges can be avoided. The speed which can be obtained by this form of car could be very high, and consequently the inventor urges it as a very practical system of rapid transit, not only in cities, but for the connection of towns and distant points.

A Franchise Awarded.

The following clipping from the Montreal "Daily Herald" of Jan. 12 wi'l be read with interest by Mr. Corriveau's numerous friends, who have many kind remembrances of courtesies received at his hands during their attendance on the Montreal convention of the National Electric Light Convention: The election in the municipality of St. Louis de Mile End was concluded at 4 o'clock yesterday afternoon, when the polling, which had lasted two days, closed on the triumphant return of Messrs. Louis Collerette and Louis Daze, the councilors who had gone to their constituents on the question of their vote giving the electric railway franchise to the Corriveau company. Mayor Villeneuve was elected by acclamation, and when the final vote in the election for councilors was counted in the Town Hall yesterday afternoon the result was as follows:

L. Collerette	420
L. Daze	420
J. B. Brunet	156
O. Lapierre	151

The Stanley Transformer.

The Stanley Manufacturing Company, of Pittsfield, Mass., since its introduction to the public, has made many improvements in the design and construction of its transformers, but no very radical changes. It has now, however, made a very important change in the matter of insulation. Transformers play a most important role in the alternating current system. The two absolute essentials in a transformer are safety and reliability, both of which factors depend upon the method of insulation.

The new method of insulation consists in imbedding the wires in and surrounding them by a substance with very high insulating properties, so that the coils form a perfectly solid mass. The cross section of the coil of one of these transformers has the appearance of a first class submarine cable. The primary and secondary coils form a solid mass, and are protected from any possible contact with the iron core by a new and ingenious method. These coils can be submerged in water indefinitely without injury to the insulation. Fig. 1 represents the ordinary tpye of 20 light capacity.

The efficiency of the Stanley transformer at full load is from 97½ to 93 per cent., depending on the size; at half load 97.1 to 90 per cent.; at quarter load 96 to 85 per cent. In the matter of regulation there is a variation of the secondary electromotive force between no load and full load of from one to one and a half volts out of 50, depending on the size. Leakage and regulation are interdependent in much the same way that efficiency and life are in electric lamps, that is, as you decrease leakage you must impair regulation, and vice verse, and therefore there is a medium point at which the best results will be obtained. Current which is being used in the primary coil is called leakage, but perhaps more properly magnetizing current. While for a single transformer the percentage of power lost in this way is small, in a large station it becomes an important question.

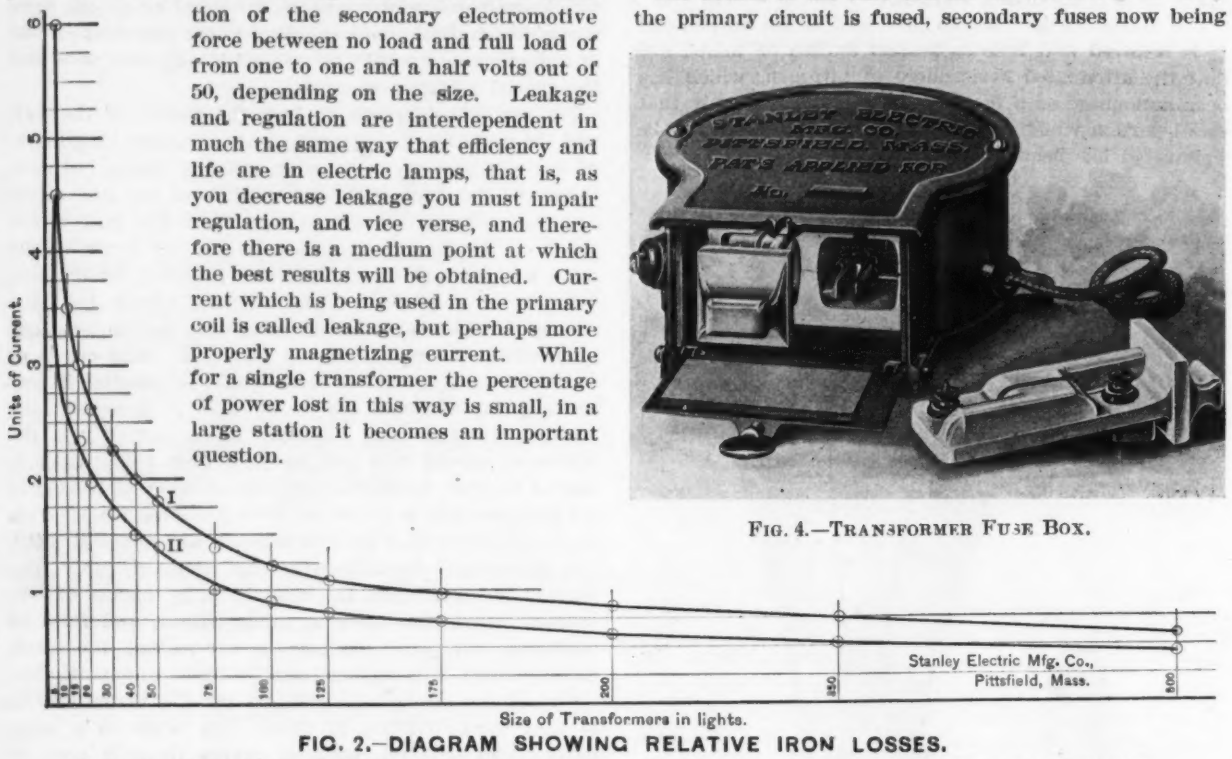


FIG. 2.—DIAGRAM SHOWING RELATIVE IRON LOSSES.

Curve I. Apparent loss = E. M. F. × leakage current. Curve II. Real loss = E. M. F. × leakage current × lag factor.

A plant in actual operation furnishing about 5,000 16 c. p. lamps, gives a good illustration of this. The average size of the transformers in the station in point is 24 lights. If this station would go a step further and rearrange its transformers so as to bring the average size up to 125 lights, the actual current fed into the line would be much less, and a still greater saving could be accomplished by using larger transformers. Any station man can readily see by a little calculation that a great deal of waste power is thus saved.

The Stanley company was perhaps the first to realize the advantages to be gained by increasing the size of transformers commonly used. There is not only a gain in the matter of leakage by the use of larger transformers, but there is also a gain in efficiency, not only because the large transformer can be made more efficient, but also because it is running a greater percentage of time than the smaller ones. The principal disadvantage in their use is the necessity of large secondary wiring, but this can be largely overcome by using 100-volt secondaries instead of 50-volt. Fig. 2 represents the saving in power obtained by the use of large transformers. The vertical divisions indicate the different sizes of transformers, and the horizontal ones units of current or "power." The relative economy of the different sizes is at once apparent.

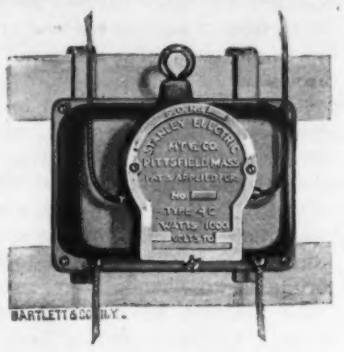


FIG. 1.—TWENTY LIGHT TRANSFORMER.

In 1891 this company made a successful transformer of 100 16 c. p. lights capacity; it is now making them of 500 lights capacity. It is not at present considered practical to make transformers of more than 250 lights capacity for outdoor use, and therefore the larger transformers are designed to be located indoors. One of these 250-light transformers is shown in Fig. 3, and is seen to be very compact.

The details of the fuse box are shown in Fig. 4. Only the primary circuit is fused, secondary fuses now being regarded as unnecessary. The fuse is double-pole, each wire or link being carried on a separate porcelain plug or block. To replace a fuse the door is dropped down by simply loosening one thumb-screw, the plug pulled out and an extra one inserted, or a new fuse wire attached to the same plug. The same size of plug is used in all sizes of transformers, and all plugs are interchangeable with each other. To change a fuse requires but a moment and is absolutely unattended by danger.

FIG. 4.—TRANSFORMER FUSE BOX.

The Stanley transformer is thoroughly constructed in every detail, and each one is subjected to several times the voltage at which it will be used before it leaves the shop. The company is confident that with this improvement it will meet every requirement of the most exacting practice even more successfully than it has done in the past.

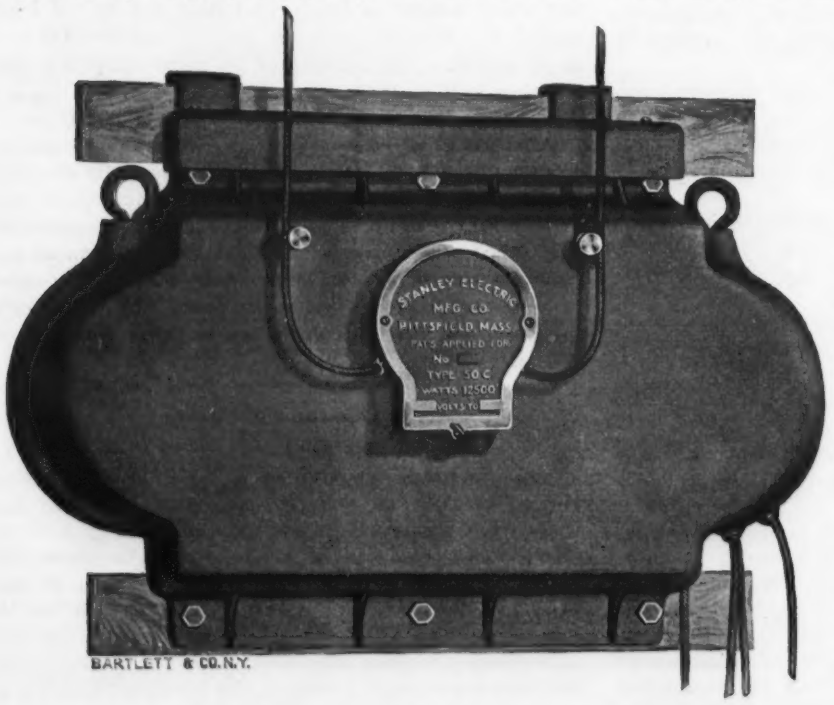
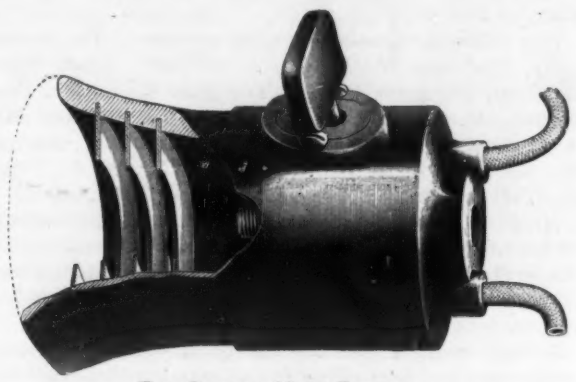


FIG. 3.—250-LIGHT TRANSFORMER, OUTDOOR TYPE.

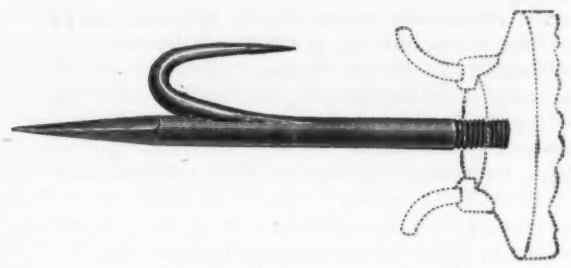
Cutter's Mine Socket.

Those who have used incandescent lamps in places where water is apt to run over them know how the so-called waterproof sockets fall short of the mark. They apparently shield the works of the socket from the dripping water, but do not prevent the moisture from creeping up on the lamp and short-circuiting the cap. The result is that the fuses are blown much too often, thus leaving the men in darkness unless they have other lamps a thand.

These defects in the ordinary rubber, glass or porcelain sockets have been considered by George Cutter in developing the socket shown in the cut. This has a well built interior (with porcelain insulations) protected by a casing of polished hard rubber. The leading-in wires are cemented into the shell, while the handle or key passes through a bushing which is made watertight by soft rubber washers. These prevent any moisture from entering the shell at the sides so that the only danger would be from the creeping of the water along the bulb of the lamp. To avoid this, the shell has a series of soft rubber rings which press against the bulb of the lamp when screwed into place, and prevent any moisture from reaching the lamp base. It is evident that such a socket can be used with safety in places where there is a steady dripping of water, and it is claimed that it can be entirely immersed without any danger from short-circuits. When used in mines it is furnished with a prong as shown in the cut, so that it can be hooked into any convenient position. The socket is made either with or without a key, and is being exploited by George Cutter, of Chicago.



THE CUTTER MINE SOCKET.



SOCKET WITH PRONGS FOR MINE USE.

NEW BOOKS.

ANNUAIRE DU BUREAU DES LONGITUDES. Paris: Gauthier-Villars et Fils, 1893. 18mo, 868 pages, figures and two magnetic charts.

Besides the practical information which it contains each year, the "Annuaire du Bureau des Longitudes" for 1893 contains articles by a number of authorities on finance, statistics, geography, mineralogy, etc., as well as the following: On the Correlation of Statical and Dynamical Electrical Phenonema and the Definition of Electrical Units, by A. Cornie; Discourse on Aerostatics, delivered before the Congress of Scientific Societies, by J. Janssen; oration delivered at the grave of Mlle. Ossian Bonicet, by F. Tesseraud; orations delivered at the grave of Admiral Monchez, by Mlle. Faye, Bouquet de la Grye and Loewy; oration by M. J. Janssen, in the name of the Bureau of Longitudes, at the Inauguration of the Statue of General Perrier at Valleraugue.

DIE ACCUMULATOREN. By Johannes Zacharias. 251 pp. Ill. Hermann Costenoble, Jena, Germany, 1892. Price, 9 marks; paper.

Mr. Zacharias' work is probably one of the most complete on accumulators published in the German language. To a great extent it consists of a summary of matter that has appeared at various times. After a short historical sketch of the accumulator and some introductory remarks, he begins with a chapter on the general principles underlying the action in the accumulators and the underlying principles of electrolysis with special reference to the accumulator. This chapter includes the various theories of the chemistry of the accumulator, together with the researches of a number of workers in this field. Chapter second is devoted to the construction of accumulators, beginning with the very earliest form devised by the American Mr. Kirchhoff, in 1861, and including all the newer forms, especially, however, those made in Germany. The next chapters treat of the construction of the retaining cell and similar accessories, the comparison of different systems and the manufacture of the plates. Chapter six treats of the efficiency, capacity and general action of the accumulator. Chapter seven, which comprises almost half of the volume, is devoted to the application of the accumulator for industrial purposes. In this he gives a description of various installations, together with a description of how to calculate accumulator stations, how to estimate their first cost and cost of operation, and like matters. concluding with a description of transportable cells and their application for railways, boats, etc. The last chapters are devoted to the accessories in accumulator stations, switchboards, rules for erecting and operating accumulators, testing them, etc.

The book is well illustrated with numerous cuts and diagrams. Unlike most German scientific and engineering works, it is, we regret to say, printed in the old style German text, instead of the Roman type which has been adopted by almost the entire civilized world.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

[Inquiries from our patrons for information relative to stocks and bonds of the various electric light and power companies are solicited, and will be answered in this column.]

NEW YORK, Jan. 21, 1893.

NEW YORK GENERAL FINANCIAL STOCK MARKET.

The course of the market during the period under review has been at variance with all preconceived ideas as to what it would be in the face of heavy gold exports. In Wall street events are often logical because they are illogical. This is an exact diagram of the present condition. It is indeed a queer situation when the Street will pass within three weeks from a period of semi-demoralization caused by gold exports into a period of strength, while gold exports still continue. The amount of gold sent out this week was $4,300,000. Notwithstanding this, prices of the industrials, which, by the way, are at present the active stocks, advanced all the way from three to five points, and closed very strong. Last week a movement was started in the grangers, based upon the belief that the Interstate Commerce bill would be so amended as to permit pooling on the part of railroads. This clause was defeated in the Senate committee this week. Notwithstanding this fact, the best line of railroad securities, after a little weakness, steadily advanced, closing at the highest point reached in some months. This was notably true of St. Paul common, Louisville & Nashville. No financial writer has yet attempted to intelligently and comprehensively explain this incongruous movement. There are some who believe that we are entering upon a period of inflation which will last until spring. Others of the more conservative class, who are in the majority, are inclined to regard the market as top-heavy. Another week will enable speculators to obtain their bearings and form much more intelligent conclusions than are now possible. The cold weather throughout the country, while seriously hampering railroad operations, has been an excellent stimulus to trade. Commercial transactions in all centres are reported to be in excess of those of the corresponding period of last year. Bank clearings show large increases, while business failures aggregate 300 as compared with 403 last year.

NEW YORK ELECTRICAL STOCK MARKET.

In General.—As prophesied by us last week, the period under review experienced a bull market. In this upward movement the electrical stocks were in the van. The advance was general throughout the list of actives on both speculative and investment buying, while the bond transactions were larger than they have been in months. There was a renewed and more persistent inquiry for the high-priced telegraph stocks, and Central & South American were bid 112½ and held at 117. This inquiry was attracted by the recent action of the company, as set forth in this column, deciding to duplicate its cable service on the northwest coast of South America. The stock is all very firmly held, and no transactions were reported. Commercial Cable recorded 170 bid and 185 asked. Mexican Telegraph received an increased inquiry through the successive days of the weeks at 180 bid and 200 asked. North American, under limited buying orders, scored a moderate advance, closing at 111½. Fifty shares of Westinghouse E. & M. assenting certificates sold at 73. We regard the active list as having scored an advance usual in periods of inflation, and believe that the upward movement has about reached its maximum. Individual causes may of course operate against a verification of this prophecy. However, in a general way, we believe that it will be verified.

Western Union.—Western Union passed par on Thursday, selling at 101 on Friday, and holding the ground again up to the close of the day. The move was generally credited to Mr. S. V. White. The buying, which put the stock above par, was distributed among a good many brokers, and was accompanied by talk of 105 for the stock next week. Some of the buyers believe that an increase in the rate of dividend was probable, although admitting that it was not quite apparent from the earnings how such an increase could be brought about. A more general view was that the stock was worth par as a sure 5 per cent. property. In this connection a prominent broker says, "Western Union is advancing because it will be a 6 per cent. stock in a year's time. Mr. J. Pierpont Morgan is known to favor an increase in the dividend, and I think there is no question but that it will be increased. The chief obstacle was Mr. Jay Gould, who, it will be remembered, resisted the 10 per cent. stock dividend as long as possible." Much of the talk in the Street in regard to the property is very bullish, although there are conservative houses who admit that the customary reaction which usually follows an advance will be shown in the course of this stock next week. The Collateral Trust five bonds were in good demand, something like 20,000 selling from 104½ to 105.

General Electric.—This stock was moderately active sustaining its opening quotation throughout the week and closing at 113¼. A feature of the week was the transactions in its 5 per cent. bonds, $165,000 selling at 100¾ to 101. We do not think that the stock has reached its highest point on the present move, and we predict slightly higher values, provided the market shows any strength next week.

Edison Electric Illuminating of New York. This stock surpassed all previous records as to price, selling at 126. The advance, as has been stated previously in this column, has been in discount of the excellent financial showing made following. The results for the year ending Dec. 31, 1892, are:

The station earnings of the company were	$942,575 23
Operating expenses, repairs and renewals	385,494 49
Net earnings of stations	$557,080 74
Income from other sources	20,446 02
	$577,526 76
Less general expenses and taxes	$102,389 15
Net earnings of company	$475,127 61

CONDENSED BALANCE SHEET, DEC. 31, 1892.

Dr.		
License under Edison patents		$3,020,000.00
Real estate, construction and property and other investment accounts	$5,119,565.78	
11,163 shares Edison Light and Power Installation Company	1,116,400.00	
683 shares New York Electric Equipment Company	68,300.00	
		6,304,665.78
Customers' accounts		143,796.40
Sundry accounts and supplies on hand		89,052.51
Cash on hand		33,736.17
		$9,591,250.86
Cr.		
Capital stock	$6,500,000	
Less installment due Feb. 3, 1893	400,000	
		$6,100,000.00
First mortgage convertible 5 per cent. bonds		3,100,000.00
Bills and accounts payable		136,837.65
Sundry accounts		2,532.11
Dividend No. 1 (due Feb. 1, 1893)		66,567.50
Reserve fund		82,355.78
Accrued interest		51,666.67
Profit and loss		51,291.15
		$9,591,250.68

INCOME ACCOUNT YEAR ENDING DEC. 31, 1892.

Dr.		
Dividends paid, 1892:		
May 1	$57,849.94	
Aug. 1	57,849.97	
Nov. 1	62,743.75	
Due Feb. 1, 1893	66,567.50	
		$245,011.16
Reserve fund		50,000.00
Accounts written off		7,510.48
Interest on bonds		78,832.00
Accrued interest on bonds to Dec. 31, 1892		48,899.17
Balance Dec. 31, 1892		51,291.15
		$481,543.96
Cr.		
Balance Dec. 31, 1891	$61,006.23	
Less dividend paid Feb. 1, 1892	54,599.88	
		$6,406.35
Net earnings 1892		475,137.61
		$481,543.96

The first five per cent. bonds showed material strength in sympathy with the course of the stock. Under comparatively large quotations, the price advanced from 117 to 120.

Central & South American Telegraph Company.—This company's stockholders met Wednesday and ratified the action of the directors in authorizing an increase of the company's capital stock from $6,500,000 to $8,000,000. The capital is for the purpose of duplicating its cable lines on the west coast of Central and South America. The new line is to go from Santa Cruz, Mexico, to Chorrilos, Peru. The steamship Silverton sailed from London Tuesday with the cable on board. The lines, it is said, will be completed about May 1.

A Western View.—A Chicago dispatch says: The Edison company is refusing to sell lamps to consumers with other plants than theirs, forcing promises to take out other plants and substitute theirs. A new lamp was sprung here recently, called the "Shaefer incandescent." It is said to be no infringement. The Edison company has begun serving notices to consumers that they will be held responsible for all infringement of the Edison lamp. It is estimated that $25,000,000 capital and 6,500 employés have been made idle by the recent decision. The Edison patent has two years longer to run. The Edison company has secured an injunction and stopped the manufacture of incandescent lamps by all the companies in Chicago. The Sunbeam and the Illinois factories stopped yesterday and temporarily laid off 400 employés.

Chicago Edison Electric Illuminating Company.—The annual report of this company shows net earnings at the rate of 32 per cent. on the stock as it stood at the beginning of 1892, and 21 per cent. on the stock as it stood at the close of the year, the stock having been increased during the year 50 per cent.

American Speaking Telephone Company.—This company held its annual meeting at 145 Broadway on Thursday. The following directors were elected: Norvin Green, John Van Horne, Thomas T. Eckert, Parke Godwin, Charles A. Tinker, Russell Sage, James D. Safford, George J. Gould, James Merrihew, Edwin Gould and J. B. Van Every. The company does no active business. It used to own telephone patents, which it sold out to the Bell company on a royalty.

NEW YORK QUOTATIONS.

	Par.	Capital outstanding.	Lowest.	Highest.	Bid.	Ask'd.
American District Tel.	100	3,825,000	51½	57	56	59
American Tel. & Cable	100	14,000,000	88	90	89	90½
Central & So. Am. Tel.	100	6,500,000	....	....	112	117
Commercial Cables	100	7,716,000	....	....	170	185
Gold Stock & Tel	100	5,000,000	..	....	100	103
Bonds	500	500,000	....	....	100	....
Mexican Telegraph	....	2,000,000	....	....	180	200
Northwestern Telegraph	....	2,500,000	....	....	102	....
Postal Tel. & Cable	...	10,000,000	....	....	62	64
Southern & Atlantic Tel	25	948,775	....	....	78	84
Western Union Tel	100	94,820,000	98⅜	101	95	96½
Real estate bonds	1,000	1,219,000	....	....	....	..
Debenture bonds	1,000	1,920,000	112½	112½	....	..
Collateral Trust 5's	1,000	8,181,000	104½	105	....	.
North American	100	39,767,200	11¼	11¾	10½	11
Brush Ill. Co. of N. Y.	50	1,000,000	....	....	30	60
Edison El. Il. of N. Y.	100	6,100,000	123½	126	124	125
" " 1sts	...	.....	117	120	...	..
" " Deb's	...	.....	....	....	....	....
Edison El. Il. of Brooklyn	100	1,500,000	...	....	106	108
" " " Chicago	100	750,000	....	....	130	145
" " " Boston	...	.....	....	....	115	125
Edison El. Lt. Europe	1,000	2,000,000	....	....	2	6
" Bonds	....	30,000	....	....	65	80
Edison Ore Milling Co	...	2,000,000	....	....	15	20
East River El. Light	100	1,000,000	....	....	....	65
General Electric	1,000	30,395,600	*112⅞	114⅛	112⅞	113¼
Debenture 5's	...	10,000,000	100¾	101	....	....
Automatic Exhibition Co.	...	2,500,000	..	....	3	5
Mt. Morris Electric	...	500,000	....	....	....	65
N. E. Phonograph	..	2,000,000	....	....	2	4
N. Y. Phonograph	...	2,000,000	....	....	2	5
N. American Phonograph	..	2,000,000	....	....	....	....
Westinghouse E. & M. Co. 1st p. 7 per cent., Cum.	50	3,755,700	73	73	....	....
E. & M. Co. Assg	50	5,333,940	....	....	....	....

* Ex dividend.

CHICAGO QUOTATIONS.

Following are the quotations of telephone and electric stocks furnished THE ELECTRICAL WORLD by C. V. Banta, Jr., 167 Dearborn street:

Telephone Stocks:	Bid.	Ask'd.	Electrical Stocks:	Bid.	Ask'd.
Chicago	200	210	Chicago Light and Power Co	116	120
Central Union	....	57½	Chicago Edison Co	170	....

BOSTON, Mass., Jan. 21, 1893.

The local market of the past week has been by far the best one we have witnessed in many weeks, and almost many months. Prices have been so well maintained at the high figures that the public and traders alike have felt the desire to be on the right side, while securities were going up. Pronounced bears seeing they were on the wrong side have become bulls, as zealous on one side as once on their old tactics. This, we presume, is what everybody predicted as soon as the new year should open. There has been naturally a slight reaction at times from highest prices, but even this did not stop the movement. A tremendous export of gold today was, as well, unable to influence the market. The great cheapness of money is, of course, conducive to stock buying. Between banks it loans freely at 3 per cent. Good call loans are made at 4 per cent.; and business paper sells as low as 4½ to 5½ per cent. Besides a general activity throughout the list, the strength of some of the local specialties shows good purchasing, and a maintained strength in their home market. Bay State Gas has responded to good buying by a rise of a point, but there was not sufficient activity to carry it again to its old figures. West End Railway is back again to 72 and over, from 69½ where it was when the year closed. Bell Telephone, which had fallen to about 200 a few weeks ago, is very strong once more at its usual price, 210.

The new preferred stock of the United Electric Securities Company, of which $750,000 is offered for sale, is, as a matter of fact, the property of the General Electric Company, and sold for its account. It was recently issued to the General company in lieu of certain securities the company had on hand, allowing a fair margin; and now the General Company makes the sale, realizing thereby quick capital for those securities that it had on hand, not representing cash or available for use as working capital. In this way both companies profit by the plan of disposal.

A recent offering of electric bonds is $20,000 six per cent. gold bonds of the Hartford, Conn., Light and Power Company. The cash cost of the plant was $311,500, against which there are out, standing only $100,000 bonds. These are secured by a mortgage of $150,000. The bonds are offered at par and accrued interest by Taylor Bros., of Boston.

The Edison Electric Illuminating Company, of Boston, has declared a regular quarterly dividend of two per cent. payable Feb. 1.

Detroit Electrical Works stock declined to a still lower figure this week on account of the announcement from the West that the capital was to be increased by the issuing of preferred stock with which a bonus of the common stock was to be given. It was to have such entire preference over common stock that it practically relegated the latter to a position where it would have little or no claim on the profits or on the property in case of a final distribution of assets. The plan was so seriously objected to, especially by the Eastern stockholders, that it has since been modified, so that the preferred and common stock will be on an equal footing in case of a final distribution of assets.

		Highest.	Lowest.	Bid.	Asked
Thomson-Houston Elec.—Series C	sh	8¼	..	8—	8⅛
Thomson-Houston Elec.—Series D	sh	8	7⅞	7¾	8
Thomson Elec. Weld	100	..	..	..	..
Thomson European Elec. Weld	100	..	..	5	7½
Westinghouse Elec.—New Com.	..	39¼	35	37⅝	38
Westinghouse Elec. Pfd	..	50	48⅝	49½	50
General Electric	..	114¼	112¾	113	113⅛
" " Pfd	..	119	116	116½	117
Fort Wayne Elec	25	13⅛	13	13⅛	13¼
Fort Wayne Elec.—Series A	sh	8	7⅞	7⅞	7⅞
Detroit Electric	20	3⅛	2⅞	..	3
West End St. Ry. Co.—Com	5	72	71	71¾	71⅞
" " " Pfd	50	85¼	85¾	85	85¼
American Bell Tel	100	210½	206	210	210½
Erie Tel. & Tel. Co	..	50½	50	50	50⅛
Mexican Tel. Co	10	90c		85c	1.00
New England Tel. & Tel. Co.	..	61⅛	60	61	61⅛
Tropical Tel. Co	..	..	..	..	..

NEW INCORPORATIONS.

The Home Electric Company, of Coudersport, Pa., capital stock $10,000, has been started to supply light, heat and power by electricity. Jas. B. Benson, M. S. Thomson and O. H. Crosby are the organizers.

The Charles E. Gregory Company, of Chicago, Ill., capital stock $50,000, has been formed to buy, sell and deal in electrical apparatus, etc. Chas. E. Gregory, D. Johnston and F. E. Drake are the parties interested.

The Beattie Zinc Works Company, of Reading, Mass., capital stock $10,000, has been formed to manufacture and sell battery zincs, etc. Josiah Hobart, Wm. F. Spinney, and Albert J. Francis are the promoters.

The Columbia Heights Electric Company, of Columbia Heights, Ill., capital stock $25,000, has been incorporated for electric light and motor purposes. The incorporators are Jas. F. Keeney Chas. D. Otis and I. N. Rice.

The Lancaster & Manheim Railway Company, of Lancaster, Pa., capital stock $250,000, has been formed to construct and operate an electric railway in that town. The promoters are J. B. Long, Walter M. Franklin and John A. Coyle.

The Sedalia Water and Light Company, of Sedalia, Mo., capital stock $500,000, has been incorporated for the purpose of constructing electric and other works. J. B. Quigley, L. P. Andrews and S. F. Rasse, all of Sedalia, are the organizers.

The Pierce Construction Company, of Leominster, Mass., capital stock $9,000, has been formed to construct electric railroads and to manufacture railway supplies, etc. The incorporators are Harry L. Pierce, Chas. E. Hudson and H. S. Pierce.

The Scranton & Pittston Passenger Railway Company, of Scranton, Pa., capital stock $90,000, has been formed to construct and operate an electric railway. Lemuel Ammerman, Louis A. Watrous and Herman P. Miller are the promoters.

The Star Electric Company, of Dubuque, Ia., capital stock $100,000, has been formed to manufacture and supply electricity, etc. F. D. Stout, B. E. Linnehan, W. S. Mole, W. J. Brown and F. B. Daniels, all of Dubuque, are the promoters.

The Lancaster & Terre Hill Street Railway Company, of Lancaster, Pa., capital stock $200,000, has been formed to construct and operate an electric railway in that town. John D. Skiles, J. Hay Brown and J. I. Hartman are the incorporators.

The Grand Ridge Electric Light, Power and Creamery Company, of Grand Ridge, Ill., capital stock $8,000, has been formed to furnish electric light and power, and to run a creamery. J. S. S. Lewis, C. A. Porter and Reuben Eckert are the organizers.

The Corona Marble Company of Vermont, of Brandon, Vt., capital stock $100,000, has been formed to manufacture, mine, etc., and to supply heat, light and power by electricity. F. E. Briggs, F. G. Swinington and D. D. Hewett, all of Brandon, are the promoters.

The Excelsior Electric Signal and Manufacturing Company, of East Omaha, Neb., capital stock $50,000, has been formed to purchase, own and operate United States patents Nos. 446,546, 447,943, 460,464, 466,520. W. N. Babcock, W. S. King and J. H. Van Dusen are the parties interested.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-176 TIMES BUILDING, NEW YORK, Jan. 23, 1893.

Mr. Wm. C. Callman, of 591 Broadway, New York City, has assumed charge of the business in the State of New York of the Feldkamp Electric Motor Company, whose factory is at Newark N. J.

Mr. F. Holman, of the Holman Electric Company, 128 Pearl street, New York, has just returned from a Southern trip and reports many large orders for the "Paradox" shade, manufactured by this company.

Proposed Extension of the Elevated Roads.—The Rapid Transit Commission at one of its recent meetings passed a set of resolutions stating that while an underground railway was the only sufficient and effective system of rapid transit for New York City, as there had been no sale of the franchise, it is necessary to provide some immediate means for the relief of the present heavy traffic and that therefore permission ought to be granted to the Manhattan Elevated Railway Company to extend its lines. In accordance with this action on the part of the commissioners, the Man

hattan company has handed them a petition for various improvements and extensions. The extensions are: first, from the Eighth street and Sixth avenue station, through Greenwich avenue and West Eleventh street to West street, and down West street to the Battery place station; second, from the Eighth street and Sixth avenue station, through Greenwich and Seventh avenues to Forty-fourth street and Broadway, up Broadway to the Boulevard and Eleventh avenue to Fort George; third, from the station at Canal street and South Fifth avenue, through Canal and Centre streets to the City Hall station; fourth, from the station at Canal and South Fifth avenue through Canal street and Watts street to the new West street line connecting on the way with the Ninth avenue line at the new Greenwich street crossing; fifth, from the station at Forty-second street and Sixth avenue to the station at the Grand Central Station; sixth, from the turn at Fifty-third street and Ninth avenue, through that street to Tenth avenue, and up that avenue to the Boulevard to join with that proposed line; seventh, from the Eighth avenue line at 149th street, through that street to Lenox avenue, down that avenue to 128th street and across to the Third avenue line; eighth, from the Suburban road station at 177th street and Third avenue up Third avenue, Fordham avenue, Kingsbridge road and College avenue to the New York & Harlem Railroad station at Fordham. All these extensions will be two track lines excepting the long line from Eighth street to Fort George and the Fifty-third street and Tenth avenue connection. This will have three tracks, so that the "L" road will have four solid three track lines—two on each side of the city. The petition asks that its trains may be propelled by either steam, electricity or compressed air.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 31, CITY TRUST BUILDING, 927 Chestnut St.,
PHILADELPHIA, Pa., Jan. 21, 1893.

The Gibson Gas Fixture Company, of Philadelphia, reports its January business as exceeding that of the corresponding month of any previous year. The sales of the Chicago branch house have very much exceeded the company's most sanguine expectations.

The Pennsylvania Electric Engineering Company, agent for the Western Electric Company, has recently sold the Steelton Heating, Light and Power Company, of Steelton, Pa., another 60-light Western Electric arc dynamo. This plant now consists of 110 arc lights and 2 000 incandescent lights of 16 c. p.

Messrs. Pedrick & Ayer, the well known machine and tool builders of Philadelphia, make a specialty of milling machines, of which they have several different designs. The last one of these machines, which is somewhat different in construction, is said to be superior to anything yet offered to the public. The use of these machines to manufacturers of electric specialties is well known, and in a measure seems to be almost indispensable.

Harry S. Smith & Co., Limited, has a contract for the installation of 400 lights at the Hotel Brighton, Atlantic City, N. J., under Dr. Drysdale's specifications. This firm is also wiring the Hotel Albemarle at the above city. Other work which this firm is now doing is the installation of an electric automatic pumping outfit in the Union League Club, of Philadelphia, and a 200 light plant for W. W. Bache's restaurant, Philadelphia. The Eddy dynamo will be used for this.

The La Roche Electric Works, of Philadelphia, is doing a very large business in the installation of electric plants, especially in Philadelphia, and all are said to have given entire satisfaction. One of these plants, recently installed in Moore's Windsor Hotel on Filbert street, this city, consists of from 600 to 700 lights, and two 250 compound La Roche machines run by a Straight Line engine manufactured by J. E. Sweet, of Syracuse, N. Y. This plant reflects much credit on the La Roche system, and Mr. Moore, proprietor of the Windsor Hotel, expresses himself as being entirely satisfied and greatly pleased with his plant.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 91, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Mass., Jan. 21, 1893.

The Harvey Hammer and Tool Company, recently burned out at Augusta, Me., will locate at Bath, Me, according to report.

The Montpelier Hardware Company has been organized as a corporation, with the following officers: D. L. Fuller, president; H. L. Dean, vice-president, and C. H. Fuller, general manager.

The Salem Electric Light Company has elected officers as follows: C. H. Price, J. F. Almy, P. W. Currier, Z. A. Gallup, I. P. Harris, G. M. Harris and S. F. Smith. Mr. Price was afterward elected president, and H. W. Batchelder treasurer. The company has made material additions to its property during the year, and has 6,000 incandescent lights installed.

The Waltham Emery Wheel Company is the largest concern of its kind in the country. Its principal owners, Clarence Tebbetts and Henry Richardson, state that it undoubtedly will be sold out to the Columbian Company, with the proviso that its business be continued in that city. A consolidation of all the companies in the country has for a long time been considered as the only way of saving the business from ruinous competition.

The East End Street Railway, of Bridgeport, Conn., has lately been sold to Col. H. H. Heft, the Standard Oil magnate, and a syndicate, part of whom are New York men. New directors have been elected, and Colonel Heft is now president, Wm. Scheerer, treasurer; G. O. Lines, secretary and general manager, and T. B. Lasher, superintendent. The price was not given out, but it is said it was nearly $800,000. The road runs from Stratford avenue, near the depot, to Stratford, and is prosperous. Colonel Heft has also made offers for the Bridgeport Horse Railroad.

The New Bedford Copper Company has declared its semi-annual dividend of $3 per share, payable Jan. 31. H. Coyle has been elected superintendent of the National India Rubber Company, of Bristol, R. I., to fill the vacancy caused by the death of Isaac Williams. Mr. Foote, late of South Framingham, has been appointed assistant superintendent. There has been a quiet survey made of a proposed electric line from Haverhill to Salem. It is to run through Groveland, Boxford, Topsfield and Danvers. The grades are usually low, and it is thought the matter will be pushed.

WASHINGTON NOTES

WASHINGTON, D. C., Jan. 21, 1893.

The East End Electric Railway.—In the case of this road the Commissioners recommend that the route be changed so as to go up Tenth street East to "B" street North, to Twelfth street East, instead of passing around Lincoln Square, as now proposed.

Mr. Chas. D. Shain, of 136 Liberty street, New York City, who is the Eastern representative of the Siemens & Halske Electric Company of America, made a short visit to this city last week in the interest of that company. It is reported that an agency for the South Atlantic States will be established here.

The Pierce & Miller Engineering Company, of New York City, has commenced the erection of apparatus to be used in the power plant for the underground system of the Rock Creek Railway. Mr. R. M. Prior is in charge of the work, which is being somewhat delayed by the extremely cold weather prevailing.

President Geo. A. Truesdell, of the Eckington Electric Railway, recently called upon the Commissioners to enter protests against the passage through Eckington of the Washington, Burnt Mills & Sandy Springs Electric Railway, a bill for the incorporation of the latter road having been at that time under consideration.

Eckington & Soldiers' Home Railway Company has issued a statement from which it appears that it carried during the year 1,383,993 passengers, the income from the same being $61.009.99. Operating expenses, including repairs, amounted to $59,683.45. During the year $15,902.28 was expended for equipment and construction.

The Metropolitan Railway Company has not yet begun regular trips. The cars, which are to use storage batteries as a motive power, appear now and then for a short time, and the officers stated some time ago that on and after Dec. 20 the entire line would be equipped with them; but this, like many promises before this one, is as yet unrealized.

The Washington & Arlington Railroad plan to occupy the aqueduct bridge and extend its tracks to Thirty-second and M streets does not meet with the unanimity of support that it was supposed it would from the petitions in favor of the proposition recently sent to Congress. A hearing will be given in the Senate district committee room on Tuesday, Jan. 17.

Mr. L. W. Spear, of Alexandria, Va., who recently resigned as secretary of the Mount Vernon Electric Railway Company, has organized a company for the purpose of building another street railway in that city. The City Council has before it an ordinance which grants to Mr. Spear and his associates the right of way over certain streets not now occupied by the Mount Vernon Electric Railway Company or the Alexandria & Fairfax Railway Company.

The American Association for Inventors and Manufacturers held its annual meeting at 426 Ninth street N. W., Washington, D. C., on Tuesday, Jan. 17, Dr. R. J Gatling, of Hartford, inventor of the Gatling gun, was re-elected president of the Association, G. G. Hubbard, Col. A. Shaw, Col. J. C. Anderson and Commissioner of Patents Simonds chosen as vice-presidents, and G. G. Maynard re elected secretary. Papers were read by Oberlin Smith and others.

The Washington, Alexandria & Mount Vernon Electric Railway Company, through Mr. Meredith, of Virginia, has introduced a bill in the House authorizing them to bridge the Potomac River between Analaston Island and the Long Bridge, and to lay tracks across the reclaimed flats north of the tidal reservoirs to the junction of B and Seventeenth streets, thence along B street to Fifteenth street and up Fifteenth street to Pennsylvania avenue.

The Mount Vernon Electric Railway.—The recent cold weather has been very profitable in so far as the Mount Vernon Electric Railway Company is concerned. The excellent skating on Hunting Creek has attracted hundreds of people to the scene, and it was found necessary to run special cars. On Jan. 1, 1,300 passengers were carried to that point. The cars used upon this line are heated by electric heaters which have proved very popular on account of their neatness and cleanliness

The Washington & Georgetown Railway.—With the amount of trouble that the Washington & Georgetown Railway Company is experiencing with its Pennsylvania avenue cable, it is quite likely that electricity will supersede it as soon as a practical underground system is brought out. The Love system, now being installed on the U street extension of the Rock Creek Railway, seems particularly adapted to this road, as but very little work would be necessary to make the change. The entire transformation could be accomplished in a short time and without stoppage of the road.

East Washington Railways.—In reporting to Congress upon several of the proposed electric railways of East Washington, the Commissioners recommended that, inasmuch as the Washington & Marlboro Electric Railway, the East End Electric Railway and the East Washington Crosstown Railway desire to cross the Eastern Branch, they be required to build a bridge across said stream along the line of "E" street East (extended), the plans and specifications for this bridge to be approved by the Secretary of War, as the Eastern Branch forms a portion of the navigable waters of the United States.

Washington, Burnt Mills & Sandy Springs Railway.—The Commissioners have reported favorably upon the bill incorporating the above company. Several amendments, however, are recommended—one putting the capital stock at $50,000, and leaving out the first route proposed entirely; one inserting a clause providing for a maximum fare of five cents, and one providing that there shall be no transfer of freight cars except to the B. & O. R. R. They also recommend the insertion of the clause providing for the payment to the District of 4 per cent. of the gross earnings of the road as a tax in lieu of personal tax.

Conduit Explosions.—There have been several explosions in the conduits of the United States Electric Lighting Company, and as yet it is all conjecture as to how they occurred. The covers to manholes have ventilating holes in them which permit the escape of gas coming from defective gas mains, and it is quite likely that these in some way became stopped, causing the gas to accumulate. But the question arises, How did this accumulation of gas become ignited? All wires are thoroughly insulated, and the explosions occurred at a time when the wires were not in use. As yet all is mystery and promises to remain so.

The condition of the Georgetown & Tenallytown Railroad, as shown by the report that is being prepared for the benefit of the stockholders, has greatly improved under the few months presidency of Mr. J. Hite Miller, and by the end of the next fiscal year it is believed a fair dividend will be paid. During the year 1891 there were 798,637 passengers carried, while in 1892 there were 953,041, an increase of 154,404 In November, 1891, the regular expenditures exceeded the receipts by $308.65, while in the corresponding month of the year just closed and the third month of Mr. Miller's presidency there was a clear profit of $378.10. In the first case there were five cars in operation and at favorable times in addition to these a freight motor was operated. In December, 1891, although there were 45,094 passengers carried the receipts fell short of the outlay $220.72, while though fewer passengers were carried in the corresponding month in 1892, they were only $219.19 short. Many important improvements have been made in the management of this road since last October. Cars now run on schedule time and are kept in perfect order. It is quite evident that, if care and enterprise will do it, Mr. Miller will make the Georgetown & Fenallytown road rank among the best managed roads of the city.

The Washington & Arlington Electric Railway.—The petition of the Washington & Arlington Electric Railway Company for permission to use the piers of the Aqueduct Bridge for the purpose of crossing the Potomac has been signed by some 300 residents of Washington and Georgetown, and over 200 of the principal land owners in Alexandria and Fairfax counties, Virginia. The charter of the road provides for the erection of a new bridge above the Three Sisters, and it was expected that arrangements could be made to construct a bridge there that would serve both for the electric cars and for one or both of the steam railroads that are seeking to cross the Potomac in this neighborhood. The question has been raised, however, whether steam railroads could make use of the bridge constructed under the Washington & Arlington road's charter, and if such is not possible it is thought that the construction of the independent bridge would be too expensive for use solely by the street railway. Hence the effort to secure the use of the Aqueduct Bridge. There has been opposition on the part of the government engineers to similar efforts in the past. The officials of the electric road state that their plan is such that it would not encroach upon the present width of the roadway, which is 24 feet. Their plan is to build out sufficiently wide to accommodate a single track upon the northwest or up-river side of the bridge. They would also strengthen the bridge in any way suggested by the United States engineers. There seems to be no good reason for this opposition, for it is an improvement and accommodation that the public in general have eagerly sought.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, Jan. 21, 1893.

The hearing of the Edison Electric Light Company vs. The Sunbeam Incandescent Lamp Company has been postponed until Feb 24.

The Massachusetts Chemical Company, of Boston, has established its Western agency at 823 Monadnock Building, Chicago, Ill., under the charge of Mr. Harry Bishop. The company deals in insulac varnishes for electrical purposes.

The Nowotny Electric Company, 30 East Fifth street, Cincinnati, O., the well known manufacturers of electrical specialties, and dealers in electric supplies, have taken up a new line in addition to their regular line of business. They buy electric light machinery of any good system that has been used and been thrown on the market. These machines are thoroughly overhauled and practically rebuilt.

Angier & Kennard have opened an office at 519 Monadnock Building, Chicago, Ill., as selling agents for electric mill and railway supplies. They represent the Butler Hard Rubber Company, the New York Rubber Company, F. H. Lovell & Co. and other firms whose goods are well known in the market. Both gentlemen composing the firm are well qualified from experience and ability to carry on the business, and there is no doubt that they will attain success.

The Electric Appliance Company will continue to represent the Emerson Electric Manufacturing Company of St. Louis as special Western selling agents for their celebrated Meston motor. The Electric Appliance Company handled this agency in a very satisfactory manner last summer, placing several hundred of the machines, the only difficulty being that the factory was unable to supply the heavy demand. Preparations have been made this season, however, to anticipate any possible demand and a large number of machines have already been sold for delivery on May 1.

The Railway Equipment Company, of Chicago, held its annual meeting on Tuesday, 17th inst., and the report of General Manager W. R. Mason showed a most satisfactory state of affairs. The business of the company has been very greatly in excess of expectations, and is daily increasing. The late devices brought out by the company have had an unprecedented sale, and are being adopted throughout the country. Mr. Mason called attention to the need of further increasing the manufacturing facilities. We understand that a very prominent capitalist has become interested in the company with the intention of still further increasing its business.

The W. D. Graves Electrical and Manufacturing Company has recently increased its capital from $25,000 to $75,000, because of the large increase in its business since the sales department has been transferred to G. P. Altenberg, at Cincinnati. The business of the company has been increased to such an extent that it is now manufacturing each month more arc lamps than were previously manufactured in 12 months. Lamps are now being shipped to nearly every State and Territory in this country, the patrons of the lamp extending from the Atlantic to the Pacific coast and from the Lakes to the Gulf Seventy-five electric light and railway companies have, within the last 60 days, adopted the Graves arc lamp, and the company is now working its factory 23 hours out of every 24.

DETROIT, Jan. 20, 1893.

The Detroit Citizens' Street Railway Company proposes to expend several million dollars in additional improvements at once. Recently the board of directors authorized General Manager Hawks to find a site for a permanent central power house for the use of the present system and all new ones. So far the company has no idea where the plant will be located but it knows what the expenditure will be. Aside from the site the cost of the plant will be $2,413,000. This is the estimate made by Charles Paine & Sons, engineers, of New York City. This estimate has been before the directors for some months. The estimate is for the power house, the machinery and the track work. The estimates are for a boiler shop, 65 × 147 feet, and the engine house, 54 × 147 feet. The plans are such as to allow extensions.

Municipal Lighting.—Aldermen Robinson, Wright and Wueltner, the committee on public lighting, met yesterday afternoon and decided to bring in a report in accordance with Mayor Pingree's idea of establishing a public lighting plant, but the committee were opposed to the scheme outlined in the bill now before the legislature to put the control of the plant in the hands of a commission, to be composed of the mayor, controller and the chairmen of the police and fire boards. The committee will submit the following resolution to the council: *Resolved*, That the representatives in the legislature at Lansing be, and are, hereby requested to have the bill now before that body, providing for the creation of an electric lighting commission for the purpose of purchasing and maintaining an electric lighting plant to light the city, so amended as to provide for the appointment of such commission by the Common Council, on the nomination of the mayor, the same as other commissions.

TACOMA, Wash., Jan. 16, 1893.

Mr. L. H. Griffith, of Seattle, has resigned his position as superintendent of the Tacoma Railway and Motor Company.

The Consumers' Supply Company has closed a contract for wiring the new six-story building of the Chamber of Commerce in Tacoma for incandescent lights.

The Northwest General Electric Company has signed a contract for the construction of three miles of electric railway in Olympia, Wash., on the west side, for a local company.

The Tacoma Railway and Motor Company has ordered ten new summer cars 24 feet in length with a seating capacity of 50

passengers. All of the work will be done in Tacoma. Work has already been commenced on the cars at the company's shops. It has been decided to vestibule a number of old cars.

ENGLISH NOTES.

(From Our Own Correspondent.)

LONDON, Jan. 4, 1893.

Electric Traction in Glasgow.—In 1894 the Glasgow Town Council will enter into possession of the tramways of that city. A short time ago a sub-committee was appointed to report on the different modes of traction. Their report has now been issued and states that the sub-committee, while clearly recognizing the advantages of electric traction and taking everything into consideration, are of opinion that the inducements it offers as compared with horse traction are insufficient at present to justify its adoption. A recommendation, however, is appended to the effect that the developments of electric traction should be carefully watched.

Electric Traction.—The Liverpool Overhead Electrical Railway will be opened on Saturday, Feb. 4, by the Marquis of Salisbury. The opening ceromony of the South Staffordshire tramway system will take place on the 31st inst. It may be mentioned in passing that the 350 volt pressure, over which there appears to be considerable merriment on your side of the water, in reality merits your commiseration, inasmuch as the company had no choice in the matter, but was bound down by Board of Trade regulation. The side overhead trolley also was not decided upon merely because it was more or less of a "novelty," but for reasons of a purely local character.

Electric Lighting Companies and Town Councils.—The Windsor & Eton Electric Lighting Company was recently brought into the police court by the Town Council of the Royal Borough for taking up the streets without previously obtaining permission of the local authority, as by law directed. The penalty for this offence is £5 fine and a further maximum payment of five shillings per square foot of pavement disturbed. Had the maximum penalty been exacted, the fine would have amounted in all to £1,180. The law, however, took a merciful view of the case and the company was only fined £2, plus a halfpenny a square foot, making in all £11 16s.

Electrical Manufacturing Business.—The meetings of the shareholders of the two big electrical manufacturing companies now in some little financial difficulty passed off somewhat better than was anticipated. The directors of the Electric Construction Corporation promised in homely language "to be good boys in future," and to do their best to develop the undoubtedly excellent manufacturing business of that concern, and with the £100,000 additional capital which they propose to raise there is no reason why the ordinary shareholders should not in good time once more get a fair dividend. Considering the terrible state of things disclosed by the recent report of the Woodhouse & Rawson United (Limited), the shareholders of that company treated their directors with much business like consideration. A "committee of consultation" was appointed, and permission was given to the directors to raise £20,000 immediately for the purpose of meeting pressing obligations, the security of the money being the floating assets of the company, *i. e.*, its stock in trade.

City Arc Lights.—The contention of the gas people that the arc light, far from being superior to gas, is inferior to it when it is confronted with the characteristic yellow London fog, is borne out so far as one may be allowed to judge without quantitative measurements by the very poor figure cut by the city arc lights at a time when whe n we are suffering from a visitation of fog. It is interesting to note in this connection that the idea, so fascinating to the mathematical mind, of surrounding arc lights with molded glass, the surface being covered with prismatic rings, for the purpose of obtaining better distribution, an idea which has long been exploded in this country, has again crept up in France. Such a globe is described by M. Frédureau in the *Comptes Rendus*. The great difficulty in London would be to keep such a globe clear of soot and dust. In this connection may be mentioned that the City of London Electric Lighting company recently asked permission to erect 21 converting stations beneath the public ways, but only obtained leave for 12 and these are to be subject to removal at the pleasure of the municipality.

Municipal Electric Lighting.—For some time past the electric lighting committee of the St. Pancras Vestry has been giving the public to understand that the municipal electric lighting station started about a year ago was an unqualified financial success. The report of the electric lighting committee presented at the last meeting of the vestry shows that this is not the case. In round figures £92,000 has been capitally expended, and during the first twelve months the outgoings amounted to £6,500 and the receipts to £7,600, leaving a balance towards sinking fund and interest of some £1,000, but as the sum required for this latter purpose is about £3,000, there is a clear loss on the year's working (not including depreciation) of £2,000. There is nothing in this particularly discreditable, considering that it is the first twelve months' working of the undertaking. On the other hand, there is nothing upon which the vestry need plume itself. The vestry of Hampstead (London) has decided to undertake the lighting of the parish under it provisional order at a cost of £25,000. The Town Council of Nottingham has decided to adopt a low pressure scheme involving an estimated expenditure of nearly £45,000. The Yarmouth Town Council has decided to light the streets of that town by arc lights and lay down a 14,000-light central station at a cost of £15,000. Southport has obtained permission to borrow £28,000 for electric lighting. The Wolverhampton Town Council has decided to recommend the adoption of the tender of the Electric Construction Corporation for £28,722 for an alternate current system. The Stafford Town Council has recommended the immediate erection of a central station at a cost of £20,000. The Brighton Town Council has decided on a further expenditure of £35,000.

Induction and Capacity on Telegraph Lines.—For some time past Prof. Silvanus Thompson has been working at the difficult problem of telephonic transmission on long lines having considerable capacity, such as the cables connecting England with the continent, the longest of which, running from Bacton to Borkum, is over 200 miles long. Some of the results of Prof. Thompson's investigations are beginning to percolate through the Patent Office to the public. In a patent, which was applied for on Dec. 21, 1891, and was finally accepted on the 21st of November last, Prof. Thompson claims a cable containing insulated conductors having inductance compensators arranged at intervals throughout the cable so as to counteract the effects of electrostatic induction. The idea of neutralizing the influence of electrostatic capacity by means of inductance is, of course, an old one in the annals of telegraphy, but hitherto, so far as is known, the neutralization has invariably taken place at either end of the line. Prof. Thompson, however, finds that the soul of success consists in placing neutralizing inductances at regular intervals along the line, the inductances being proportional to the capacity of the section which it is proposed to annul. Experiments on an artificial cable have shown that the device enables one to speak through a submarine circuit 200 miles long. Of course, if Prof. Thompson's anticipations are anything like fulfilled in practice, the comparatively easy problem of harmonic and high speed telegraphy through submarine lines is solved. Leaving out considerations of cost and the possibility of exactly neutralizing electrostatic capacity in this manner a purely mechanical objection arises from the fact that the Thompson cable will at intervals have different cross-sections, owing to the necessity of inserting the inductive coils. It is instructive to note in this connection, that in a paper read before the Institution of Electrical Engineers in 1879 by Mr. Willoughby Smith on "The Workings of Long Submarine Cables," he made the following suggestive remark, "From the results of this and similar experiments, I was under the impression that by a judicious distribution of electromagnets on subterranean lines greater speed might be obtained."

Electricity in England in 1892.—As far as pure electrical science is concerned, the past year has not been particularly eventful, the most striking investigation being that of Profs. Dewar and Fleming on the resistance of metals and alloys at the boiling point of oxygen, an investigation which showed that absolutely pure metals tended to arrive at zero resistance at absolutely zero temperature. Another event, which may have far-reaching consequences, was the final report of the Board of Trade Electrical Standards Committee, which commenced work in December, 1890, and only concluded its labors on Nov. 29 last. The papers read at the Institution of Electrical Engineers during 1892 have not, with the exception of the lecture by Mr. Nikola Tesla, been remarkable for their novelty, although several contributions of considerable practical interest and value have been made. Toward the end of the year the composition of the council and the method of electing associates have been somewhat sharply criticised both inside the Institution itself and in the technical press. In the opinion of many people the council does not sufficiently accurately represent the members who are at the present moment the life of the Institution, even if they do not actually form the majority. I refer to those engaged in heavy electrical engineering practice. It is also thought by some that it is time that further precautions were taken to prevent the election of undesirable individuals. The electricity supply business has slowly but, I think, surely advanced during the past twelve months. In the metropolis the only new ground broken has been in the city, where the street arc lighting is practically complete, and considerable progress has been made with the supply of current to private customers. The energies of central station engineers in this country are now devoted to the saving of every possible penny and the maintenance of an uninterrupted supply under all conditions of load. Municipal electric lighting enterprise has, if anything, been more active during 1892 than during any other former twelve months. I should be within the mark in stating that since the beginning of the year town councils have spent or definitely decided to spend a sum of not less than £100,000 on electric lighting stations. Electric traction, on the other hand, has, if anything, retrogressed. A side overhead trolley line has, it is true, come into operation in South Staffordshire, but two accumulator lines have gone out of operation and a third has been worked at a loss. The Central London Railway is still in the distant future, and the Liverpool Overhead Railway has not yet commenced working. The only redeeming feature seems to be the fact that the City and South London Railway is now working at a fair profit. In telegraphy the most important event has been the decision of the government, upon which they immediately acted to inaugurate a complete system of coast telegraphy and to appoint a Royal Commission to inquire into the larger question of connecting outlying lighthouses and lightships with the shore. This Commission has now recommended that five lighthouses and a certain number of lightships shall at once be connected with the shore by cable. Electrical litigation has been very rife, the battle commencing on Feb. 23 with the action brought by Mr. Lane Fox against the Kensington & Knightsbridge Company for infringement of his patent claiming batteries as reservoirs of electricity in conjunction with a constant potential system; a patent which was in the end upset. In the autumn actions still *sub judice* were brought by Dr. Hopkinson against the St. James & Pall Mall Electric Light Company for the infringement of his three-wire patent, and by the National Telephone Company against Mr. Graff-Baker for alleged disturbance of their Leeds circuits by the working of his electric cars. On April 5 the Brush compound winding patent was finally disposed of in the House of Lords. The last few weeks of the year witnessed the somewhat unpleasant exposure of the shaky state of the electrical industry in this country, but good rather than evil will probably come from the public knowing that which the initiated were already perfectly well aware of.

News of the Week.

THE ELECTRIC LIGHT.

Socorro, N. M., desires electric lights.

Waterville, Wash., has decided to lease the light plant and water works for two years.

The Village of Hudson (Mich.) is $3,000 in debt and has decided to economize by shutting off its electric lights.

Lewiston, Ida.—A joint company has been formed to purchase the franchise and property of the Lewiston Electric Light Company. The new company contemplates moving the plant to a point nearer the town and increasing its equipment.

THE ELECTRIC RAILWAY.

Minneapolis, Minn.—An ordinance for a single track electric line on Third street has been before the Council.

The Dayton Street Railroad Company, of Dayton, O., will change the motive power on the Third street line from horses to electricity. The Silvey storage battery system is to be used.

Natchez, Miss.—On Jan. 5, the Natchez City Council passed an ordinance authorizing the Natchez Street Railroad Company to equip with electricity of either the storage or overhead trolley system.

The Wichita (Kan.) Electrical Railroad has been sold by the Sheriff under a mortgage of $300,000. The property was bought in by the bondholders, capitalists of Boston and New Hampshire. There will be a reorganization of the company, but the management will remain in the same hands.

The Brooklyn, Bath & West End Railroad, which was originally known as the Gunther Railroad, and was the pioneer route to Coney Island, has been purchased by E. E. Denniston the representative of the syndicate of capitalists which has been investing heavily recently in Brooklyn surface railroads. The road has not made any money for some years, owing to the sharp competition, and the amount paid for the property, it is said, was only between $500,000 and $600,000. The route, however, is regarded as one of the finest to the Island, and should the road pass under the control of the new Traction company, which recently purchased the Atlantic avenue road, and the electric trolley be substituted for steam on the West End road, there would be a complete trolley system established between the South Ferry in Brooklyn and Coney Island. It is believed that this scheme is involved in the purchase of the road.

PERSONALS.

Mr. S. G. Booker, manager of the Fidelity Carbon Manufacturing Company, of St. Louis, Mo., was in town last week. Mr. Booker reports having a very successful Eastern trip.

Dr. Cornelius Herz was placed under arrest on Jan. 19, at the Tankerville Hotel, Bournemouth, Eng. Dr. Herz was so ill, however, that his physician refused to allow him to be moved and a guard was placed over him. Notwithstanding his illness he has made energetic preparations to contest the effort to extradite him.

Mr. J. W. Lindsey, formerly with the Excelsior Electric Company, and now superintendent of the general electric construction business of Fred. L. Wolfram, met with a serious accident a few days ago, having been caught in some shafting. Both legs were fractured, but he is now on the road to recovery.

Mr. Geo. E. Fisher, manager of the Commercial Electric Company, is spending his vacation with his wife in the orange groves of Florida, and in a recent communication to THE ELECTRICAL WORLD suggests St. Augustine as a most delightful place to hold the meeting of the National Electric Light Association at some future date.

MISCELLANEOUS NOTES.

Bay City, Mich.—The Bridge Commissioners are considering the advisability of substituting electricity for steam for swinging the Third street bridge.

The University of Wisconsin is anxious to extend its departments of mechanics and engineering. The buildings now used as shops were designed to accommodate at the most 75 students. The present number in this department is 173, and next year there will probaby be 225. The capacity could be easily doubled by the building of a north wing two stories high. This would enable the rapidly growing department of electrical engineering to make adequate provision for the apparatus acquired by gift and purchase. The cost of such an extension is estimated at $7,900, and there is also needed a forge room and factory, which would cost about $4,400. The total amount needed by the Department of Mechanics and Engineering is estimated at $34,000.

Industrial and Trade Notes.

The Shultz Belting Company, of St. Louis, Mo., has issued an attractive calendar reminding the public that its belting belts the earth.

The Commercial Electric Company, of Detroit, Mich., has sent out a neat calendar containing a handsome engraving of one of its well known machines.

The Phœnix Automatic Filter Company, of Racine, Wis., has favored its friends with a handsome calendar with an engraving of Gerome's "Last Prayer of the Martyrs."

The Stanley Manufacturing Company, of Pittsfield, Mass., has issued a very attractive little catalogue describing its new transformers. Every detail is carefully explained, and the numerous cuts are unusually good.

George F. Blake & Company, New York, Boston, Philadelphia and Chicago, has issued a pamphlet containing the results of a trial of the fly-wheel, high-duty, automatic cut-off, pumping engine of its manufacture. A remarkably high efficiency was attained.

Mr. Stephen D. Barnett, treasurer and manager of the Positive Lock Washer Company, of Newark, N. J., left last week for the West. Mr. Barnett reports the sale of his company's washer as enormous, the orders being far in advance of the production.

The Ball & Wood Engine Company, 15 Cortlandt street, New York City, by Bartlett & Co., has sent out a very attractive catalogue, illustrating and describing its well known engines. This company manufactures engines adapted to a variety of work, and especially for electric light and railway plants.

The Hawke Electric Company, 174 Summer street, Boston, Mass., has purchased from Mr. H. C. Hawks his entire construction business. Mr. Hawks has accepted the position of treasurer and manager of the company, which will carry on a general electrical construction and supply business.

The Central (Colo.) Electric Supply and Manufacturing Company is the name of a new company which was recently incorporated at Pueblo., Colo., and which will deal in wholesale and retail electric supplies, and will construct and sell engines, machinery, etc. E. M. MacDermott is vice-president and general manager.

The Hall Signal Company, of New York and Chicago, has issued a very handsome series of catalogues from the press of Bartlett & Co. These describe respectively the following subjects: Signal protection, automatic audible signals, block signaling and electric interlocking signals. Besides being very artistically gotten up, they contain a great deal of valuable information on these subjects, and numerous illustrations of unusual excellence and interest, to explain the operation of the Hall Signal Company's apparatus.

Queen & Co., Incorporated, Philadelphia, have sold nearly all the Ayrton & Perry ammeters and voltmeters which they advertised so extensively at reduced prices, but a few still remain, which are offered at a mere fraction of the original manufacturing cost; for instance, an ammeter with capacity of 400 ampères being placed at $16. Any one wanting a portable instrument for general testing, where great accuracy is not required, will find it very advantageous to purchase now before the stock is entirely exhausted. Descriptive circular No. 355 will be mailed by the makers upon application.

The Oerlikon Manufacturing Company, of Zurich, Switzerland, whose three-phase dynamos, motors and transformers we have had occasion to refer to frequently in our columns, has just issued a very neat illustrated catalogue descriptive of its railway systems and machinery, in which it gives a short discussion of the comparative values of horse and electric traction, and an illustrated description of its two electrical roads in Switzerland, the cuts for which include some attractive views of Swiss scenery as seen from its Murren road in the Bernese Oberland. The description includes illustrations, details and data of its railway machinery.

The Lodge & Shipley Machine Tool Company, of Cincinnati, O., has recently purchased the drawings, patents, patterns, good will, etc., of the Newton Machine Tool Company, as set forth in the following communication from C. C. Newton: "I have this day sold my entire drawings, patterns, patents, good will and all the right and title to the gear cutting engine and automatic gear cutting machines, as illustrated on pages 25 and 26 of my 1892

catalogue, to 'The Lodge & Shipley Machine Tool Company, Harrison and Culvert streets, Cincinnati, O.,' and respectfully recommend the public to the purchase of these machines from 'The Lodge & Shipley Machine Tool Company.'"

The Kolon Battery.—It is seldom that a large electrical house indorses a primary battery in any way, and in consequence the following letter from Charles Wirt, electrical engineer of the Electrical Supply Company, to Mr. Converse D. Marsh, 136 Liberty street, New York City, has special significance: "Answering yours of Jan 4, would say the writer has had one of your cells running a phonograph for about six weeks. That is the only test it has received thus far. This work, of course, is light. Your battery does it very well, and shows that it is capable of keeping in condition for at least two or three weeks with a single charge. This is an unusually good result. If we get any further points regarding the battery will communicate with you."

The Clayton & Lambert Manufacturing Company, of Ypsilanti, Mich., are rapidly making a reputation for themselves with their gasoline firepots, paint burners and plumbers' and turners' tools, many of which are finding their way into the hands of electrical construction companies who have occasion to use goods of this class. They as manufacturers deal only with jobbers but assist the latter in their sales by providing them with literature descriptive of their wares. To enable them to do this to the best advantage they have established a complete job printing office of their own, from which they supply every jobber with descriptive circulars, each with his own name and address as agent imprinted thereon. In addition they also furnish a complete pamphlet catalogue with the jobber's own display advertisement on the cover and a sketch of his business inside.

Alexander-Chamberlain Company, 126 Liberty street, of which Mr. Harry Alexander is manager, reports business extremely brisk. Among the orders recently filled may be mentioned the installation of the Wilder fire alarm system in the city of Cohoes, N. Y., also a storage plant in the Tivoli Woolen Mills, same city; an incandescent plant in the works of J. B. & J. M. Cornell, Twenty-sixth street and Eleventh avenue, New York City; an incandescent plant in Woodbine, N. J.; an incandescent plant for the Brooklyn Bridge Cold Storage Company's warehouse, Frankford street, New York; the Cheesebrough Manufacturing Company's building in Brooklyn, N. Y.; Richard Berger, architect—eight-story building, 13 to 19 Washington place, New York; an eight-story building at 828 Broadway, New York, and others. This company is also the New York agent for the Riker motor.

Queen & Co., Incorporated, Philadelphia are congratulating themselves upon the increasing demand for their "Magnetic Vane" ammeters and voltmeters, as evidenced by the fact that more than twice as many of these instruments were sold by them in 1892 as in the preceding year. This advance is perhaps not astonishing when efficiency and cost of the apparatus are considered, but it shows a degree of appreciation on the part of purchasers that is very significant. The "M. V." instruments are adapted for constant switchboard use, and voltmeters as well as ammeters can be left in circuit constantly, a feature of great importance to the central station manager. The makers are manufacturing in large quantities to supply demands which come from all over the United States. A number of prominent dynamo building companies have adopted the above type to install with isolated plants for incandescent lighting and for power circuits. Descriptive circular No. 420 recently issued by Queen & Co. contains further information of value, and will be mailed upon application.

The Jenney Electric Motor Company, of Indianapolis, Ind., reports the following among its December sales: Swan & Lane, Boston, Mass., two 1-h. p., one 3-h. p. motor; Emil Grah, Toledo, O., one 1-h. p. and one 35-h. p. motor; Brown-Ketcham Iron Works, Haughville, Ind., one 10-h. p. motor; Light, Heat and Power Company, New Albany, Ind., one 3-h. p. motor; Electrical Engineering and Supply Company, Syracuse, N. Y., one 1-h. p.; Toledo Consolidated Street Railway Company, Toledo, O., one 35-h. p.; Commercial Club, Indianapolis, two 300-light dynamos; Minnesota Brush Electric Company, Minneapolis, Minn., one 1-h. p., one 3-h. p. and one 5-h. p. motor; New Dennison Hotel, Indianapolis, two 600-light dynamos; The William Powell Company, Cincinnati, O., one 80-kilowatt generator, three 10-h. p. motors and one 5-h. p. motor; C. E. Jones & Bro., Cincinnati, one 3-h. p., one 5-h. p. and one 20-h. p. motor; Crane & Breed Manufacturing Company, Cincinnati, O., one 1-h.p., three ½-h. p. motors; C. J. Gardner, Indianapolis, one 100-light dynamo; O. R. Olsen, Indianapolis, two 5-h. p. motors; Wiley-Warner Electric Company, Beloit, Wis., one 2-h. p. motor; Kokomo Street Railway Company, one 3-h. p. motor; J. A. Everitt Seed Company, Indianapolis, 100-light dynamo; Toledo Street Cleaning and Improvement Company, one 5-h. p. motor; Masters & Veneman, Evansville, Ind., one 5-h. p. and one 3-h. p. motor; Conant Bros. Furniture Company, Toledo, O., one 300-light dynamo; Brown-Ketcham Iron Works, Haughville, Ind., one 7½-h. p. motor; Kemper-Thomas Paper Company, Cincinnati, one 150-light dynamo; Moore Packing Company, Indianapolis, one 400-light dynamo; Indiana Bicycle Company, one 600 light dynamo and one electro-plating machine.

Business Notices.

Transformers rewound and repaired. Write for prices. The Hill Manufacturing Company, Salem, Va.

Oil Filter for sale cheap; send for prices to Purity Oil Filter Manufacturing Company, 901 Water street, Pittsburgh, Pa.

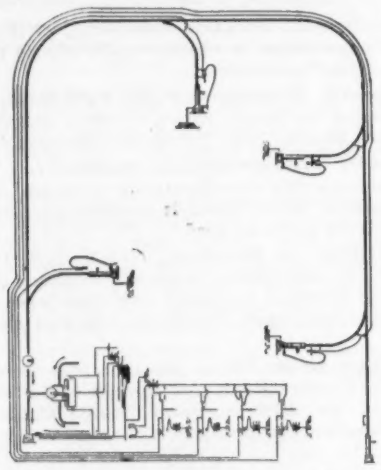
Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

[In Charge of W. A. Rosenbaum, 177 Times Bldg., N. Y.]

UNITED STATES PATENTS ISSUED JAN. 17, 1893.

489,931. Pneumatic Dispatch or Transit System; Henry Clay, of Philadelphia, Pa. Application filed Oct. 26, 1889. In a pneumatic dispatch system the combination of a single tube circuit having at one end an air current creating device and a transmitter for inserting carriers into said tube, the other end of said tube being open to the atmosphere, and having a receiving device for delivering carriers from said tube, sub-station inlet and outlet tubes joined to one or the same side of said main tubes, and carrier transmitting and delivery devices for said sub-station.



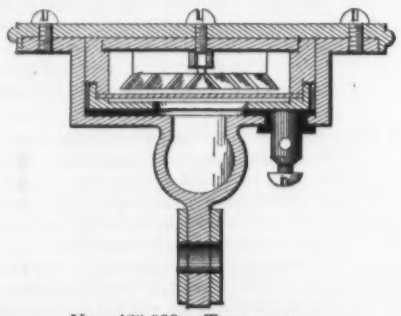
No. 489,932.—Pneumatic Dispatch or Transit System.

489,932. Pneumatic Dispatch or Transit System; Henry Clay, of Philadelphia, Pa. Application filed Oct. 26, 1889. In a pneumatic dispatch tube system a combined receiver and transmitter having a normally closed movable sleeve or door which is opened to insert the carrier into the sytem, a normally closed plate or valve which opens to admit of the exit of a carrier from the system, movable valves and actuating mechanism interposed between said movable valves and sleeves.

489,938. Electric Battery; John H. Davis, Detroit, Mich. Application filed March 27, 1892. In a primary battery, the combination of a carbon element, a zinc element, and an insulator interposed between the two, constructed of soft rubber and having grooves in the periphery.

489,983. Electric Cut Out; William B. Potter, Lynn, Mass. Application filed July 5, 1892. The combination with a box having two chambers separated by a septum, of a cover provided with an extension or lug adapted to overlap the septum, one of the chambers having a lateral opening.

489,990. Telephone; Chas. E. Scribner, Chicago, Ill. Application filed June 1, 1888. A carbon transmitter disc electrode provided with inclined concentric rings forming deflecting surfaces.



No. 489,990.—Telephone.

490,011. Electric Meter; Fernando J. Dibble, Peabody, Mass. Application filed Nov. 21, 1891. A contact arm and prime actuator therefor, combined with a movable contact to co-operate with the contact arm, and actuating mechanism to impart to the contact an intermitting movement, with a greater movement between some of the intermissions than between others.

490,012. Electric Telemeter Transmitter; Fernando J. Dibble, Peabody, Mass. Application filed Nov. 21, 1891. In a telemeter system, a rotating shaft, a contact arm moved by variations in the speed of rotation of said shaft, a movable contact, an electromagnet in circuit with said contact, its armature, and an indicating device actuated by movement of said armature.

490,013. Electric Telemeter Transmitter; Fernando J. Dibble, Peabody, Mass. Application filed Nov. 21, 1891. In a telemeter system, a movable contact arm, two co-operating movable contacts between which said contact arm moves, two transmitting magnets arranged in local circuit respectively with said contacts, and having their armatures connected to move said contacts, combined with a pole changer operated by said armatures, a main line circuit controlled thereby, polarized relays in said main line, and receiving devices controlled thereby.

490,014. Electric Telemeter System; Fernando J. Dibble, Peabody, Mass. Application filed May 12, 1892. In a telemeter system, the combination of a rotating shaft, a contact arm moved by variations in the speed of rotation thereof, a movable contact, an electromagnet, its armature, a speed-indicating device actuated by movement of said armature, and an annunciator actuated by changes in the direction of rotation of said shaft.

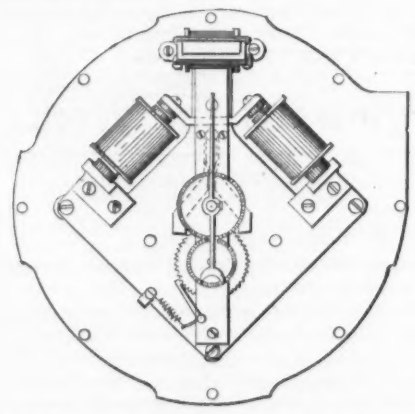
490,028. Trolley; John C. Love, Chicago, Ill. Application filed May 17, 1892. A traveling contact device for electric railways, comprising a supporting bar, a main arm pivoted thereto and adapted to swing in a vertical plane, a spring applied to throw the arm upward, two trolleys or contact pieces, two arms supporting the contact pieces, the arms being pivoted to the main arm and adapted to yield downwardly independently of each other, the main arm being provided between its ends with two pivotal or swivel joints, one affording rotary motion of outer end of arm on a longitudinal axis.

490,064. Telegraphy and Telephony; Fred. H. Brown, Chicago, Ill. Application filed Feb. 27, 1891. The combination, with a normally closed electric circuit, of a diaphragm arranged therein, a lever in said circuit having a contact point, a spring for holding said lever normally in electrical and mechanical contact with said diaphragm, and means for raising said lever out of contact with said diaphragm, whereby a telegraphic message may be transmitted over said circuit.

490,081. Commutator Brush and Holder; James F. McLaughlin, Philadelphia, Pa. Application filed March 31, 1890. A collector for commutators of dynamos and electric motors, consisting of a block composed of two sections of solid conducting material, hinged together.

490,082. Electric Heater; James F. McLaughlin, Philadelphia, Pa. Application filed April 28, 1892. An electric heater, consisting of a conductor of high electrical resistance, embedded in burnt clay, coated with glazing or enamel.

490,161. Electric Alarm Clock; Joseph A. Nadeau, Detroit, Mich. Application filed Sept. 2, 1892. The combination with a lock adapted to be mounted upon a door and comprising a metallic case, a latch and a bolt controlled by a tumbler, of a battery, and electric signal circuit wires including said battery and signal, a contact piece upon the interior of said casing insulated therefrom and having two horns, one of which is adapted to contact with the latch and the other adapted to contact with the tumbler of the lock when the door is opened, and circuit wires having one terminal secured to said contact and the other to the case of the lock.



No. 490,014.—Electric Telemeter System.

490,178. Electric Circuit Breaker; Elihu Thomson Swampscott, Mass. Application filed Oct. 28, 1892. The combination of a multiple contact circuit breaker with means for impeding or retarding the sudden rush of increased volume of current through the contact or contacts which may be opened last.

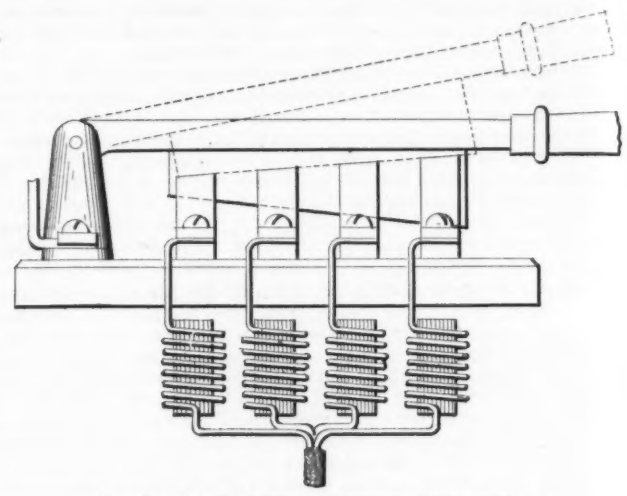
490,183. Commutator Brush; Carl O. C. Billberg, Philadelphia, Pa. Application filed Sept. 2, 1890. The herein described electrical commutator brush or contact, consisting of copper or equivalent metal, on the entering edge with a backing of carbon or similar material on the leaving edge.

490,202. Mechanism for Testing Watch Balances and Hair Springs; George E. Hunter, of Elgin, Ill. Application filed July 2, 1892. As an improvement in apparatus for testing balances and hair springs in combination with the doubly coiled electro-magnet, an electro-magnet in circuit with each of said coils, an armature subject to the influence of both of the latter magnets, and an independent circuit-closing device for each circuit through the double coils.

490,203. Method of Testing Watch Balances and Hair Springs; George E. Hunter, Elgin, Ill. Application filed July 2, 1892. The method of testing balances and hair springs which consists in vibrating the same number of times that a standard balance or spring would vibrate in a definite interval of time, in unison with a standard time-piece and employing in connection therewith an indicating mechanism that is actuated only when the balance or spring varies from the standard.

490,211. Automatic Releasing Device; Hans P. Nielsen, Alameda, Cal. Application filed Sept. 14, 1892. A releasing device consisting of a bracket having a curved foot, a swinging bar pivoted to said foot, a trip catch for holding and releasing the upper end of the bar, an electromagnet and armature for operating the catch, and a hitching or fastening bolt resting in the curved foot and locked between the bar and bracket when the bar is set and released by the swinging of the bar when tripped.

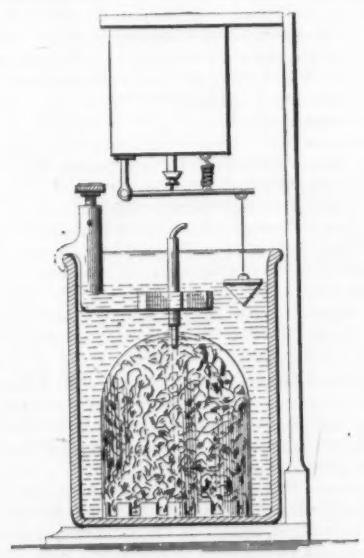
490,231. Galvanic Battery; Noah M. Powell, Galesburg, Ill. Application filed Dec. 19, 1891. The combination with a battery cell of a bracket supporting the same, said bracket also supporting a supplying tank for the cell and the valve and float arranged to admit the material contained in the tank into the cell.



No. 490,178.—Electric Circuit Breaker.

490,248. Electric Railway System; Thomas Harris, Detroit, Mich. Application filed Dec. 28, 1891. The combination of a power line, a working conductor in sections normally disconnected from the power line and normally connected to a return conductor, an electromagnet for each section, the armature of which connects the section to the power line and cuts out the preceding section, and means for actuating said magnets by a derived current from the power line, the same consisting of a push for connecting the initial section of the working conductor with a power line, a traveling contact for connecting the ends of adjoining sections of the working conductor and circuits connecting the sections of the working conductor with the return conductor, said circuits containing the electromagnets with the cut-outs.

490,254. Secondary Battery; Henry Herbert Lloyd, Philadelphia, Pa. A battery plate or electrode comprising a conducting support and complemental active material, or material adapted to become active, and distance pieces or separators covering the support and provided with transversely ranging apertures disposed opposite the active material, or material adapted to become active, and with longitudinally ranging and staggering channels.



No. 490,231.—Galvanic Battery.

490,256. Electrically Heated Soldering Iron; George R. Meitzler, Cincinnati, O. Application filed March 31, 1892. In combination with an interiorly heated soldering tool, an attachment to carry soldering fluid, adjustably connected with the tool, a snout for carrying a wick connected to this attachment and means to hold the attachment in its adjusted positions.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.